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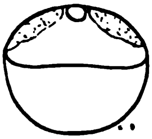

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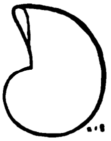

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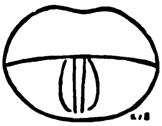

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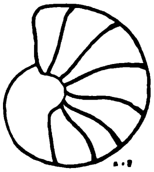

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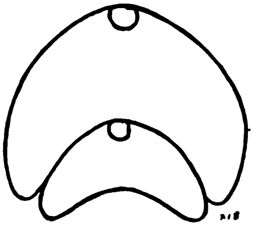

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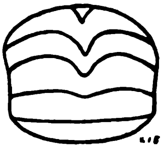

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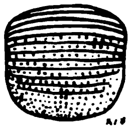

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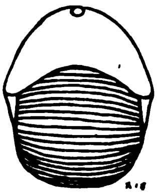

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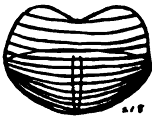

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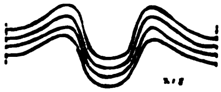

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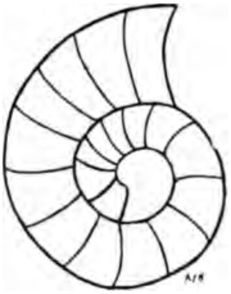

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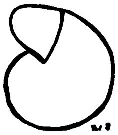

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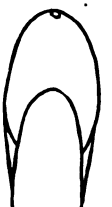

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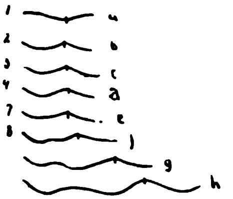

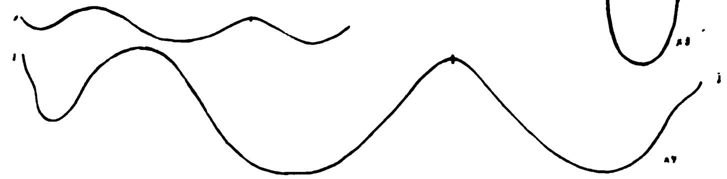

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[THIRD SERIES.]

ART. I.—*The Inconsistencies of Utilitarianism as the Exclusive Theory of Organic Evolution*; by Rev. JOHN T. GULICK.

Natural Selection an Exclusive Theory with some Biologists.

IN a previous article, entitled "Divergent Evolution and the Darwinian Theory,"* I dwelt chiefly on the need of a bionomic theory that should explain polytypic, as well as monotypic, evolution. One of the chief deficiencies in Darwin's discussion of the "Origin of Species," is that he does not distinguish with sufficient clearness the conditions that are necessary for the transformation of an original species into a new species, when the former disappears in the process, leaving the latter to occupy its place, and the conditions that are necessary for the production of two or more species from one original species. In this paper it may be instructive to examine a vigorous attempt that has been made so to expound the theory of natural selection (which Darwin considered as inadequate to cover all the forms of monotypic evolution,) that it shall serve as the full explanation of both monotypic and polytypic evolution in all organisms lower than man. By confining our attention to Mr. Wallace's very interesting and suggestive volume on "Darwinism," we shall be better able to judge of the possibility of producing a self-consistent theory on this basis; but we should bear in mind that the same view is maintained by many naturalists, and that parallel statements abound in their writings. Mr. Wallace's volume not only embodies the mature reflections of one of the joint authors of the theory of natural selection, but it fairly represents that phase of biological theory which considers diversity of natural selection through exposure to different environments the only cause of divergence. The following passage will show the exclusive nature of his theory: "A great body of facts on the one hand, and some weighty arguments on the other, alike prove that specific characters have been, and could only have been, developed and fixed by natural selection because of their utility. We may admit that among the great number of variations and sports which continually arise many are altogether useless without being hurtful; but no cause or influence has been adduced adequate to render such characters fixed and constant throughout the vast number of individuals which constitute any of the more dominant species."—*Darwinism*, p. 142. This is in strong contrast with the following passage from the close of the Introduction of the sixth edition of the "Origin of Species," which is the last one that received the revision of the author: "I am fully convinced that species are not immutable, but those belonging to what are called the same genera are lineal descendants of some other and generally extinct species, in the same manner as the acknowledged varieties of any one species are the descendants of that species. Furthermore, I am convinced that Natural Selection has been the most important, but not the exclusive, means of modification." On page 421 of the same edition, Darwin calls attention to the fact that this passage has "been placed in a most conspicuous position" in the different editions of his work, and complains of the writers who misrepresent his conclusions on this point.

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* This Journal, vol. xxxix, pp. 21–30.

Facts that are Neglected or Denied.

Though Darwin maintains that besides the inherited effects of use and disuse and the direct action of the external conditions there are other forms of variation leading to permanent modifications of structure independently of natural selection (*Origin of Species*, 6th London ed., p. 421), he does not attempt to explain how these divergences arise. Neither Darwin nor Wallace appears to have observed, that, as in domestication, the isolated breeding of other than average forms, in whatever way it is secured, is the one necessary, and always effective, cause of divergence, so, in nature, wherever there arises the isolated breeding of other than average forms, there divergence will be produced; or that, as exposure to different environments is only one of the causes that lead isolated bands of men to desire and select different types of variation in the same species of animal, so exposure of wild species to different environments is only one of several classes of causes that may subject isolated portions of one of these species to different forms of selection, producing divergence; or, again, that as differences in the uses to which men put an animal are not necessarily useful differences, so the differences in the uses which isolated portions of a species make of the environment, though they produce diversity of natural selection, leading to permanent divergence, are not necessarily useful differences. These, with other allied doctrines, which were presented in my paper on "Divergent Evolution Through Cumulative Segregation," have received adverse criticism from Mr. Wallace in the work mentioned above. He says: "In Mr. Gulick's last paper (*Jour. of Linn. Soc.*, Zoology, vol. xx, pp. 189–274), he discusses the various forms of isolation above referred to, under no less than thirty-eight different divisions, with an elaborate terminology, and he argues that these will frequently bring about divergent evolution without any change in the environment or any action of natural selection. The discussion of the problem here given will, I believe, sufficiently expose the fallacy of his contention, but his illustrations of the varied and often recondite modes by which practical isolation may be brought about, may help to remove one of the popular difficulties in the way of the action of natural selection in the origination of species." (Note on p. 150).

In this passage Mr. Wallace seems to take issue with each and all of my propositions; but after a careful study of his whole discussion, one cannot but be in doubt whether he fully dissents from any of them. This uncertainty arises either from his failing to recognize distinctions which I have made, or from ambiguities and inconsistencies in his own statements.

Extending the meaning of Natural Selection does not save the Theory.

He represents me as contending that divergent groups are frequently found in which the action of natural selection is wanting. He here fails to distinguish between the absence of diversity in the action of natural selection and the absence of any action of the same principle. I have never maintained that any species can long escape the action of natural selection; but I have that natural selection cannot produce transformation of a race unless it secures the propagation of other than average forms of that race; that it cannot be a cause of divergence unless to this condition is added the independent generation (i. e., isolation) of groups that are subjected to some diversity in its action; and, that, in isolated groups, some of the divergent characters may be due to other causes of transformation. In the passage I have quoted from p. 142, he expresses great confidence in the proof that all specific characters are developed and fixed by natural selection; but in the discussion that follows concerning the influence of natural selection, he claims as belonging to this principle sets of influences which are usually included under sexual selection, and which he cannot regard as due to the reactions between the species and its environment. (See *Darwinism*, pp. 282–5), and, even then, it is found too narrow to cover all the facts of specific divergence; for, when he comes to consider the origin and development of accessory plumes, he has to abandon the theory to which he has clung through the greater part of the book. Speaking of the enormously lengthened plumes of the "bird of paradise and of the peacock," he says, on page 293, "The fact that they have been developed to so great an extent in a few species is an indication of such perfect adaptation to the conditions of existence, such complete success in the battle of life, that there is, in the adult male at all events, a *surplus of strength, vitality and growth power, which is able to expand itself in this way without injury*. That such is the case is shown by the great abundance of most of the species which possess *these wonderful superfluities* of plumage. * * * *Why, in allied species, the development of accessory plumes has taken different forms, we are unable to say, except that it may be due to* that *individual variability* which has served as the starting point for so much of what seems to us to be strange in form or fantastic in color, both in the animal and vegetable world." (The italics are mine.) According to the theory he has elsewhere maintained, *these superfluities* of form and color which are not controlled by natural selection should present, "a series of inconstant varieties mingled together, not a distinct segregation of forms" (p. 148); but in this passage he teaches that they have assumed different forms in allied species. On p. 141 he maintains that characters which are neither beneficial nor injurious are from their very nature unstable and cannot become specific, while here he offers a suggestion as to how they have become specific. There is then a problem that presses for solution, namely, the explanation of permanent divergence in characters that are useless without being hurtful (p. 142), unless he considers his suggestion "that it may be due to individual variability" an adequate explanation; and I presume he does not. On page 142, he says of characters that are "useless without being hurtful:" "No cause or influence has been adduced adequate to render such characters fixed and constant; but in speaking of "the delicate tints of spring foliage, and the intense hues of autumn," he says: "As colors they are unadaptive, and appear to have no more relation to the well-being of the plants themselves than do the colors of gems and minerals. We may also include in the same category those algæ and fungi which have bright colors—the red snow of the Arctic regions, the red, green, or purple seaweeds, the brilliant scarlet, yellow, white, or black agarics, and other fungi. All these colors are probably the direct results of chemical composition or molecular structure, and being thus normal products of the vegetable organism, need no special explanation from our present point of view; and the same remark will apply to the varied tints of the bark of trunks, branches and twigs, which are often of various shades of brown and green, or even vivid reds or yellows" (p. 302). He here seems to admit that instead of useless specific characters being unknown, they are so common and so easily explained by "the chemical constitution of the organism" that they claim no special attention.

Inconsistency in extending the meaning of Environment.

If Mr. Wallace accepts the definition of natural selection which makes it the survival of those members of a species which are best fitted to its environment (and this is the scope he seems to assign to it in the earlier half of Chapter V where the matter is under special discussion), then he ought to admit that changes in a species produced by the action of the members of the species on each other although they are adaptive are not due to natural selection. If, on the other hand, natural selection is made to include the actions and reactions of the species on itself (and this he does on pages 282–5), then certainly he ought to admit that there may be changes in the action of natural selection without any change in the relations of the species to the environment. One way to escape this dilemma is to extend the definition of the environment so as to include every influence that affects the species, whether it is within the species, or external to it; but this reduces his doctrine, that without change in the environment there is no change in the organism, to the fruitless truism that without some cause there is no change in the organism. An example of Mr. Wallace's extending the meaning of the environment so as to include the action of the members of a species on each other, is found on page 149. After mentioning several arguments intended to show the impossibility that isolated portions of a species should diverge while exposed to the same environment, he remarks, "It is impossible that the environment of the isolated portion can be exactly like that of the bulk of the species. It cannot be so physically, since no two separated areas can be exactly alike in climate and soil; and, even if they are the same, the geographical features, size, contour, and relation to winds, seas and rivers would certainly differ. Biologically, the differences are sure to be considerable. The isolated portion of a species will almost always be in a much smaller area than that occupied by the species as a whole, hence it is *at once in a different position as regards its own kind.*" He then enumerates several differences in the biological environment that are liable to occur; but the point I wish now to note is, that he mentions as one of the differences in the environment the "*different position as regards its own kind.*" This is exactly the difference which, in so far as it is the prevention of intercrossing and the consequent unification of endowments and habits, constitutes isolation; and unless he is able to show that this difference is incapable of producing any divergence, his contention is unsustained. But he here yields the point at issue, by mentioning this amongst the effective differences. The only way to escape the force of his concession is to claim, as he virtually does here, that isolation, being the separation of the isolated fragment from the influence of the original stock, is in itself a difference in the environment. By taking this position, however, he involves himself in another contradiction; for, if isolation is a difference in the environment, why does he deny that it has a direct influence in producing change in the organism?

Diversity of Natural Selection during exposure to the same Environment.

Another discrepancy in Mr. Wallace's theory is that, while he rightly assigns great importance to diversity of natural selection arising from divergent habits in appropriating the resources of the same environment, exhibited by different sections of the same species occupying the same area, he, nevertheless, insists that the representatives of a species, isolated in different areas of the same environment, will be neccessarily subjected to the same influences from natural selection, and will inevitably maintain the same characters and of course, the same habits. That he believes divergent habits may arise, when the divergent groups are occupying the *same area*, and are prevented from crossing simply by the divergence of habits, will be seen by the case of the varieties of wolves mentioned on p. 105, and by some of the cases mentioned on pp. 108 and 117; also by the statement, on p. 119, that—"When one portion of a terrestrial species takes to a more arboreal or a more aquatic mode of life, the change of habits itself leads to the isolation of each portion," and by a similar statement at the bottom of p. 145. That he believes there can be no change, either of habits or structure, when portions of the same species are isolated in *different areas* under the same environment, appears from the statement on p. 149, that—"If the average characters of the species are the expression of its exact adaptation to its whole environment, then, given a precisely similar environment, and the isolated portion will inevitably be brought back to the same average of characters." And this he maintains will be the case even "if we admit, that, when one portion of a species is separated from the rest there will necessarily be a slight difference in the average character of the two portions."

Does the Difference in the Environment increase with each successive Mile?

If the divergences presented by the Sandwich Island land molluscs are wholly due to exposure to different environments, as Mr. Wallace argues on pages 147–150, then, there must be completely occult influences in the environment that vary progressively with each successive mile. This is so violent an assumption that it throws doubt on any theory that requires such support. Of all the suggestions made by Mr. Wallace concerning possible and inevitable differences in the environments presented in the successive valleys, it seems to me not one meets the requirements of the case, or throws any light on the subject. The one suggestion which is quite applicable as an explanation is the one already quoted that "the isolated portion is at once in a different position as regards its own kind." This is, I believe, a most potent difference, which (as Mr. Wallace's language seems to indicate), is directly introduced by isolation, and (adhering to the meaning usually given to environment,) is not at all due to difference in the environments presented in the different areas.

Unstable Adjustments disturbed by Isolation.

There is a sentence in another chapter of Mr. Wallace's book which attributes to isolation (though without recognizing the important results that must follow) just that kind of influence in introducing a certain class of physiological divergences, which I claim for it in introducing, not only physiological, but also psychological and morphological divergences. I claim that there is, in many species, more or less variation with unstable adjustment, in the habits which determine what forms of food it shall appropriate, and that, when a few individuals of such a species (the offspring perhaps of a single female) are isolated, this adjustment is often so disturbed by the failure of the few individuals to completely represent the average character of the species and by their being freed from competition, and wide interbreeding with those of their own kind, that divergent habits of feeding are formed. I further claim that for the production of this result it is not at all necessary that the environments presented in the isolated districts should differ in any respect. Indeed if all but one pair of a variable species should be destroyed, the descendants of that pair, remaining in the same area and under the same environment, would probably differ more or less from the original stock. Those that breed together must have habits that enable them to do so; and the offspring of those that interbreed widely will for the most part, inherit the powers and habits that enabled their ancestors to interbreed widely; but if the offspring of a single family are carried to an isolated area presenting the same environment, there will be nothing to ensure the perpetuation of exactly the original powers and habits, unless the power of heredity is such that each pair is sure to transmit the complete average character of the whole species; and this is not the condition of all species that pair, if of any. Within the limits of each freely interbreeding portion of a species a mutual harmony and adjustment of habits is preserved, because it is the condition of propagation within those limits; but between portions that are prevented from interbreeding there is nothing but heredity to prevent divergence in the kinds of adjustment; and in variable species, the probability is that divergence will in time show itself more or less distinctly. Though Mr. Wallace considers this reasoning fallacious when applied to divergence in habits he uses an exactly parallel reasoning in the portion of the following passage which I designate by italics. "*It appears as if fertility depended on such a delicate adjustment of the male and female elements to each other, that, unless constantly kept up by the preservation of the most fertile individuals, sterility is always liable to arise. . . . So long as a species remains undivided, and in occupation of a continuous area, its fertility is kept up by natural selection; but the moment it becomes separated, either by geographical or selective isolation, or by diversity of station or of habits, while each portion must be kept fertile inter se, there is nothing to prevent infertility arising between the two separated portions.* As the two portions will necessarily exist under somewhat different conditions of life, and will usually have acquired some diversity of form and color—both which circumstances we know to be either the cause of infertility or to be corelated with it—the fact of some degree of infertility usually appearing between closely allied but locally or physiologically segregated species is exactly what we should expect" (p. 184–5). Notwithstanding this statement he does not seem to have grasped the idea, that in the geographically isolated portions as well as in the others, the "different conditions of life" of which he speaks, may be the different relations to the environment into which the separated portions are brought by their divergent habits, without any reference to inevitable differences in the size and contours of the different areas or in any other features of the environments; and that the divergence in the habits may be directly due to the prevention of interbreeding between separated portions which inevitably differ in average character, especially if they are very small portions.

Isolated portions differ in varying degrees from the average character of the Species.

The italicized portion of the passage last quoted attributes to isolation, in stronger language than I should be willing to use, a direct influence in producing divergence in the adjustments on which fertility in the different portions of the species depend. I should prefer to say that in *some species* the adjustments on which fertility depends are so delicate that, adjustments producing perfect fertility within one intergenerating portion of the species, will not produce fertility in another portion that has been long isolated. I do not make my statements so sweeping as his concerning the divergent influence of isolation on any one class of characters, but I include all classes of inheritable characters, in sexually producing organisms, as coming under its influence. I also insist that the direct influence of isolation in producing divergence is in proportion to the degree of segregation, which varies immensely in different forms of isolation which are equally complete as preventives of intercrossing. A very stable and homogeneous species may be divided by geological subsidence into two large sections, each represented by a vast number of individuals. In such a case the difference in the average character, and consequently the degree of segregation, of the two sections will be infinitesimally small, and the influence of the isolation thus produced will chiefly consist in its preserving in the different sections any diversities that may arise in the effects of natural selection, or of other principles of transformation. The isolation between the land animals of Ireland and Britain, which Mr. Wallace cites as adverse to my theory, is of this kind. Again, there may be transportation and isolation of very small fragments of a very variable species. In such a case separation may involve a degree of segregation that from the first produces perceptible divergence. Again, the process by which the isolation is produced may be in itself segregative, in that it brings together those endowed in some special way, causing them to breed together, and preventing them from breeding with others. This is especially the case with Sexual, Social, and Prepotential, Segregation, and in some degree with Industrial Segregation. Isolation thus produced is in its very nature segregative, and would result in divergence if diversity of natural selection did not arise in the different sections of the species. Segregation with divergence may also be produced by natural selection or some other principle of transformation co-operating with some form of isolation that of itself is not perceptibly segregative. As segregation of other than average forms always produces divergence, and without it there is no divergence, I claim that it is the fundamental principle of divergent or polytypic evolution. Natural selection, which is the exclusive propagation of those better adapted to the environment, when it results in the preservation of other than average forms, produces confluent or monotypic evolution; but it is never the cause of divergence, except when co-operating with some principle of isolation in such a way that the two principles produce segregation. Failure to recognize these distinctions, prevents Mr. Wallace from understanding my theory, and leads him to represent me as claiming for isolation all that I claim for segregation.

Incompatibilities arise during Positive Segregation.

On pages 173-186, Mr. Wallace maintains that "Natural selection is, in some probable cases at all events, able to accumulate variations in infertility between incipient species" (p. 174); but his reasoning does not seem to me conclusive. Even if we grant that the increase of this character occurs by the steps which he describes, it is not a process of accumulation by natural selection. In order to be a means of cumulative modification of varieties, races or species, selection, whether artificial or adaptational, must preserve certain forms of an intergenerating stock, to the exclusion of other forms of the same stock. Progressive change in the size of the occupants of a poultry-yard may be secured by raising only bantams the first, only common fowls the second, and only Shanghai fowls the third year; but this is not the form of selection that has produced the different races of fowls. So in nature rats may drive out and supplant mice; but this kind of selection modifies neither rats nor mice. On the other hand, if certain variations of mice prevail over others through their superior success in escaping their pursuers, then modification begins. Now, turning to p. 175, we find that in the illustrative case introduced by Mr. Wallace, the commencement of infertility between the incipient species is in relations to each other of two portions of a species that are locally segregated from the rest of the species, and partially segregated from each other by different modes of life. These two local varieties, by the terms of his supposition, being better adapted to the environment than the freely interbreeding forms in other parts of the general area, increase till they supplant these original forms. Then, in some limited portion of the general area, there arise two still more divergent forms, with greater mutual infertility and with increased adaptation to the environment, enabling them to prevail throughout the whole area. The process here described, if it takes place, is not modification by natural selection. The natural selection of which he speaks does not arise till, with each advancing step, a new and complicated adjustment (which introduces the two new forms, each with unabated fertility with its own kind but with diminished fertility with the other kind) has been attained by some other process. That other process is the one described in the passage I have already quoted from pp. 184–5, where, according to my apprehension, the cause of divergence is more correctly stated than it is in the passage now under consideration. In the latter part of my paper on *Divergent Evolution through Cumulative Segregation* I have shown that the different kinds of incompatibility, preventing complete fertility between incipient species (and there called forms of Negative Segregation), cannot arise except as accompaniments of Positive Segregation in some form; but that, having once arisen in connection with partial Positive Segregation, they increase from generation to generation by a law that is quite distinct from natural selection. It was also shown that endowments only partially segregative (as, for example, somewhat divergent habits of feeding), when not concurrent with any forms of cross incompatibility, are liable to be obliterated by crossing; but, when associated with segregate fertility and cross infertility, will increase from generation to generation, even if the mongrels are as well adapted to the environment as the pure forms. I at the same time called attention to the fact that, when associated with some form of partial positive segregation (as divergent habits of feeding, or segregative sexual and social instincts), greater vigor, of pure forms, as contrasted with the mongrels, would have the same effect as their greater fertility. In other words, Segregate Vigor would preserve a partially segregated variety as effectual as Segregate Fecundity.

Incompatibilities will disappear unless preserved by Positive Segregation.

Mr. Wallace has given a very instructive computation on pages 181–4; but it does not seem to me to prove, as he supposes, that infertility between the individuals of a species cannot increase "unless correlated with some useful variation," but that it cannot arise, except as a transitory variation, unless associated with some positively segregative principle, causing those to pair together which are fertile with each other. My contention is that, without some positive form of segregation fecundity and cross sterility can never arise; and that after it has arisen under segregation, no amount of correlation with useful variation will preserve it, if the positive segregation is removed. If, for example, all the species of humming birds were brought together in one country, and were deprived of all segregative habits and instincts, it certainly would not require many generations to reduce them to one species. If equally adapted to the environment, the species that would succeed in perpetuating itself would be the one represented by the largest number of individuals; or if several species were entirely cross fertile and were in the aggregate represented by a larger number of individuals than any other similar group of species or than any single species, then, the resulting species would be the hybrid descendants of this most numerous group. All the other species would become extinct through failing to mate with "physiological complements."

Why any need of distinctive Recognition Marks for those whose Ancestors had but one set of Marks.

An example of one of the effects of divergence being treated as if it were the primary cause of divergence is found on pages 217–228 and 284, where the need of distinctive characters for easy recognition is given as the chief cause of divergence in calls, odors, and colors. The importance of distinctive characters by which the members of a species may distinguish their mates from those of other species cannot be exaggerated; but how does it happen that the descendants of one stock which had originally but one set of such characters, have become segregated into groups, needing distinctive marks. By confounding the problem of successive, monotypic adaptation with that of coexistent, polytypic adaptation the real causes of divergence have been obscured and misapprehended. The diversity of Sexual and Social Selection, which Mr. Wallace in these passages speaks of as natural selection, is due to diversity of sexual and social instincts which in their turn have been produced by different forms of segregation. For a fuller exposition of this subject I would refer to my paper on "*Divergent Evolution through Cumulative Segregation*" (Linn. Soc. Jour. Zoology, vol. xx, pp. 234–8). The principles which I have called Sexual and Social Segregation, Mr. Wallace has mentioned in several places under the name "selective association," or "selective isolation," but he does not recognize the fact that, whenever this principle segregates forms whose immediate ancestors were not segregated, it must be the direct cause of divergence; and that, when divergent forms that have arisen under Industrial and Local Segregation are brought together through increase of numbers, this principle is often the one cause preserving varieties that would otherwise be obliterated. With plants whose pollen is distributed by the wind, and probably with both vegetable and animal forms whose fertilizing elements are distributed by water, Prepotential Segregation plays the same role as the segregative instincts of higher animals. As this principle depends on the greater rapidity with which the male and female elements of the same variety or species combine, as contrasted with the elements of different varieties and species, we might call it isolation through selective impregnation, just as Mr. Wallace has called the instinctive segregation, "isolation through selective association." Whatever names we give these two principles, they must be important factors in divergent evolution.

Segregation produces Domestic Races, why not Species?

Mr. Wallace seems to be opposed to the idea that some form of isolation is essential to divergence; but in his argument he yields so much that I cannot but think his opposition is largely due to his misinterpreting the theory. Mr. Romanes has mentioned eight or ten forms of isolation; and Mr. Wallace says I have discussed thirty-eight forms; but neither of us claim that these are the only possible forms; nor do we claim that any form of this principle is essential to the transformation of one species into another when the original one disappears in the process. The phrase "new species" as used by Mr. Wallace in the following passage is ambiguous; but the second sentence seems to indicate that he is here discussing divergence as well as simple transformation. He says: "Most writers consider the isolation of a portion of a species a very important factor in the formation of new species, while others maintain it to be absolutely essential. This latter view has arisen from an exaggerated opinion as to the power of intercrossing to keep down any variety or incipient species and merge it in the parent stock. But it is evident that this can only occur with varieties that are not useful, or which, if useful, occur in very small numbers." . . . (p. 144). Near the end of the same chapter, after presenting arguments in favor of this position, and after reviewing some of the facts which I have presented concerning the divergences of Sandwich Island land molluscs, he remarks—"We have, however, seen reason to believe that geographical or local isolation is by no means essential to the differentiation of species, because the same result is brought about by the incipient species acquiring different habits or frequently a different station; and also by the fact that different varieties of the same species are known to prefer to pair with their like and thus to bring about a physiological isolation of the most effective kind" (p. 150). Except that he has used "physiological isolation" where I should have used psychological segregation, this last passage is as completely in accord with what I have presented in my paper on "*Divergent Evolution*" as it could have been if he had copied my statements. But how is this passage, and one of similar import on page 185, to be reconciled with his own statement just quoted from page 144. On pages 217, 218 and 226, he bases his argument for the importance of different coloration in closely allied species on the obvious necessity for means "to secure the pairing together of individuals of the same species," if a new species is to be kept "separate from its nearest allies." He here assumes the fundamental fact on which the theory of segregation rests. All that is wanting is its recognition as a universal principle on which all permanent divergences, whether varietal or specific necessarily depend. In the formation of domestic variations it is fully recognized; for he says, "It is only by isolation and pure breeding that any specially desired qualities can be increased by selection" (p. 99). If experimental biology shows this to be a constant law, is there any good reason for not applying it in the general theory of organic evolution? Seeing it is admitted that artificial selection, unaided by isolation, is of no avail in producing divergent races, how can it be claimed that natural selection, unaided by isolation, is of any avail in producing varieties and species. Again, as in domestication, the segregate breeding of other than average forms always produces divergence, have we any reason to doubt that, when the same process takes place in the grouping of organisms in a natural state, the result will also be divergence?

The discrepancies to which I have referred are it seems to me due to deficiencies in the theory which Mr. Wallace maintains in common with many others. These problems that drive the exclusive utilitarian into various inconsistencies, can, I am convinced, be consistently explained by the theory of Divergence through Segregation.

26 Concession, Osaka, Japan.

ART. II.—*The Southern Extension of the Appomattox Formation;*[*] by W J McGEE.

CONTENTS: Introduction, p. 15—General Characters and Relations, p. 19—Geographic Distribution, p. 28—Hypsographic Distribution, p. 30—Stratigraphic Relations, p. 31—Taxonomy, p. 33—Sources of Materials, p. 34—Interpretation, p. 35.

INTRODUCTION.

IN a paper entitled "Three Formations of the Middle Atlantic Slope," published in the American Journal of Science early in 1888,[†] a distinctive late Tertiary formation, well displayed on the Appomattox river in eastern Virginia, was defined and named after that river; and its principal characters, its distribution, its stratigraphic relations, and its probable age were briefly recorded. The formation was then known to consist of a series of predominantly orange-colored, nonfossiliferous sands and clays, resting unconformably upon Miocene and older formations, and unconformably overlain by the Columbia formation; it was known to expand southward, from a thin and discontinuous bed exposed in a narrow belt on the Rappahannock river, so rapidly as to form a terrane many miles in width on the Roanoke; and it was inferred to represent at least a part of the Orange Sand of Hilgard and other southern geologists.

The several lines of research concerning the phenomena of the Middle Atlantic slope recorded in this paper have recently been extended southward into the Carolinas, Georgia, Alabama, and Mississippi; and some of the results of the work are deemed worthy of publication.

The Coastal Plain commencing in the Middle Atlantic slope at Sandy Hook extends southwestward to the southeastern angle of the continent forming Florida, and thence westward and southwestward to the boundary of the national domain on the Rio Grande. Throughout the sweep of nearly two thousand miles from the mouth of the Hudson to the lower Mississippi, the geographic division so trenchantly defined in the Middle Atlantic slope is well marked, although its inner boundary is less conspicuous in the south than in the north; for in the Southern Atlantic and Eastern Gulf slopes it is commonly crossed at right angles by the rivers (the Alabama alone marking it for a considerable distance), while in the Middle Atlantic slope the principal waterways depart from their normal direction to follow its course, and thus give origin to one of the most strongly marked physiographic features of

[*] Read before the Geological Society of America, Dec. 27, 1889.

[†] Third Series, vol. xxxv, pp. 120–143, 328–330, 367–388, 448–468.

the globe. Yet in the south as in the north the boundary is the most important structural line of eastern United States: it marks the junction of the unconsolidated and practically undisturbed Neozoic clastics on the seaward side, at first with the greatly disturbed crystallines, and then with the corrugated, folded, and everywhere completely lithified Paleozoic strata of the southern Appalachians; on reaching it every stream, great and small, is broken by a rocky rapid, a great fall, or a cascade, and these lines of rapids, falls, and cascades extend from the Roanoke almost to the Mississippi. And in the Southern Atlantic and Eastern Gulf slopes, as in the Middle Atlantic zone, the boundary is an important cultural line: Most of the leading southern cities are built at the falls of the rivers, and their industries are determined by the water-power which the rivers afford; the rivers are commonly navigable below and unnavigable above the falls, and the original means of traffic were thus diverse, and this diversity persists in some measure to-day; while the soils on opposite sides of the boundary are essentially distinct, and so the industries growing out of the soil and its products are commonly sharply contrasted. Among the southern cities located on the fall-line are Columbia, Augusta, Macon, Columbus, Montgomery and Tuscaloosa. The Coastal Plain lying between this great structural, physiographic, and cultural boundary of Nature's drawing and the still more trenchant boundary marked by the shores of the Atlantic and Gulf, is a lowland zone, concentric with the continent save as expanded by the Floridian peninsula, and scored radially by drainage lines, of which many expose its structure.

This is the area in which the Appomattox formation is found; and throughout the greater part of this area, the formation is well developed and wonderfully presistent in composition, structure, and stratigraphic relations.

In order to set forth clearly the phenomena of the Appomattox formation in its southern extension, it is necessary to note briefly the characteristics in the southern states of the two great data-formations representing the beginning and the ending of Neozoic time in the Middle Atlantic slope—the Potomac and the Columbia.

About its type locality (the District of Columbia), the Columbia formation exhibits two phases, i. e., a *fluvial phase*, consisting of brick-clay or loam graduating downward into a gravel or bowlder bed; and an *interfluvial phase*, consisting largely of debris derived from the immediately subjacent formations, rearranged, intermixed with a variable element of far traveled material brought down by the rivers, and re-deposited in a sheet of variable thickness, ranging from a trifling veneer near the fall-line and at high levels to a considerable bed of stratified deposits toward the coast. In the Southern Atlantic and Eastern Gulf slopes, the formation in like manner consists commonly of two principal phases and several local varieties; yet all are connected by stratigraphic continuity: In North Carolina the relations displayed in the District of Columbia are maintained, save that the interfluvial phase becomes progressively more and more sandy in crossing the state from north to south, and finally passes into the essentially continuous veneer of sandy loam or fine sand completely covering the seaward portion of the Coastal Plain from the Neuse river to Mobile bay; in South Carolina the fluvial phase becomes transformed into a sandy or silty loam flanking the rivers in low terraces locally known as "second bottoms," while the interfluvial phase is represented by the wide-spread mantle of pine-clad sands stretching scores of miles inland from the coast—though the fluvial phase is sometimes removed and the interfluvial phase is more profoundly eroded than in either higher or lower latitudes; in Georgia the two phases of the formation are similar to those displayed in South Carolina save that both have suffered less from erosion; in central Alabama the fluvial phase is represented upon the principal rivers by extensive "second bottom" loam (which is, on the Chattahoochee, indistinguishable from the Columbia loam either in hand specimens or in hillsides), while in southern Alabama the loam becomes sandy and expands into a superficial mantle of pine-clad sands entering the state from Georgia in a hundred-mile zone which narrows to a twenty-mile belt west of Mobile bay; in northeastern Mississippi the fluvial deposits are similar to those of northern Alabama, and to the southward they pass into the low-lying sand-plain entering the State from the east; but toward the mouth of the Mississippi the sand-flats narrow, and the sands pass into a series of silts and clays with intercalated sand-beds which are, according to Johnson,* stratigraphically continuous with, and but another phase of, the Port Hudson of Hilgard; while in western Mississippi the fluvial phase of the Columbia passes into and is finally replaced by the vast body of loess with subjacent gravel beds flanking the Mississippi river. These various deposits are stratigraphically continuous, and form a single and indivisible genetic unit; they were evidently laid down during a single submergence of the southeastern coast, extending from the terminal moraine at the mouth of the Hudson to and beyond the Mississippi river; and the local variations in composition and structure are evidently due to simple and easily ascertained local conditions.

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*The correlation of the Port Hudson with the Columbia represents the only link in the series which was not established by personally tracing stratigraphic continuity from section to section and from phase to phase on the ground. It is just to say that the coast sands and subjacent clay beds of southeastern Mississippi, the Port Hudson, and the loess with its basal gravel bed, were independently and antecedently correlated by Mr. Lawrence C. Johnson of Mississippi, and that the well defined Columbia deposits of the Roanoke river have been stratigraphically connected with the coast sands and "second bottom" deposits of North Carolina by Prof. Joseph A. Holmes of the University of North Carolina, both of whom are engaged in geologic investigations of the Coastal Plain under the auspices of the U. S. Geological Survey and the direction of the author; and it is a source of gratification to be able to state that the observations and inferences of these geologists are in all respects corroborative of the work recorded herein.

The Columbia formation represents the first great episode of cold in the Pleistocene; and by reason of the recent work on its southern extension, it is now possible to map with approximate accuracy the geography of the southeastern part of the continent during that episode.

In its type locality the Potomac formation is a brackish water littoral deposit made up of gravel and cobble-stones of quartz and quartzite (derived respectively from the Blue Ridge and from the veins intersecting the Piedmont gneisses), arkose (derived immediately from the Piedmont schists and granites), sand, derived from all these sources, and a considerable element of clay; and its age is probably early Cretaceous or late Jurassic—the abundant plant remains indicating the former period, and the less abundant vertebrate remains denoting the latter. South of the Appomattox river the continuity of the terrane is broken by erosion, and its surface is sometimes concealed by newer deposits; but exposures are sufficiently frequent to warrant the conclusion that the Potomac formation is stratigraphically continuous with the beds of gravel, arkose, sand, and clay exposed at many points in the Carolinas and still better displayed at Augusta, Macon, Columbus, and other points in Georgia, and so with the body of like materials stretching from the Chattahoochee to the Tombigbee in Alabama—the Tuscaloosa formation of Smith and Johnson.*

The Potomac formation is now connected, by actual observation of stratigraphic continuity between its most widely diverse phases, and by identification at many intermediate points, from its type locality on the Potomac to and beyond the Tuscaloosa (Warrior). It is indeed variable in structure and materials in different parts of its extent; but the several variations are easily traceable to local conditions of genesis. Viewed in the large way, it is a single and indivisible genetic unit, representing the first episode in the development of the Coastal Plain of the Atlantic and the Gulf with its submarine extension—the first episode in continental growth after the later throes of

* Bulletin U. S. Geol. Survey, No. 43, 1887, p. 105.

Appalachian deformation; it tells of profound depression, pronounced seaward tilting, and prolonged submergence of the young continent, whereby preëxistent physiography was greatly modified, the cis-Mississippi land shrinking to half its area with such attendant climatal changes that the fauna of land and sea was changed and the land flora revolutionized more completely than in any other eon of the earth's history; yet the record of the formation is so readily susceptible of interpretation that, despite the remoteness of the period, and despite the obscurity of later records, it is already possible to map with approximate accuracy the geography of the Potomac epoch. So the formation is a structural and chronologic unit from which the stratigraphy and the geological history of the Coastal Plain may be reckoned.

GENERAL CHARACTERS AND RELATIONS.

As exposed north of Roanoke river, the Appomattox formation consists of moderately regularly stratified sand or clay, with occasional intercalations of fine gravel, commonly of pronounced orange hue, and without fossils so far as known. Farther southward these characters are generally maintained; but local variations appear from place to place, and certain other moderately constant features are displayed.

In eastern-central North Carolina the formation is notably variable and heterogeneous over the thinly covered eastern extension of the Piedmont crystallines now culminating in the continental projection of Cape Hatteras, (which has been during past ages an even more conspicuous geographic feature than to-day); and its features are evidently connected with the proximity of the crystalline strata. Thus, at Wilson there is the usual partition into several regular and rather heavy (2 to 5 feet) strata, the usual orange hue, and the usual distribution of quartzite and quartz pebbles either throughout the several strata or in bands or pockets; but the lowermost stratum exposed in the northern part of town is largely composed of arkose, slightly rearranged and sparsely intermixed with fine quartz pebbles; and there is some admixture of arkose in the superior layers. Then, half a mile south of Wilson, a nine-foot railway cutting displays the usual heavy and moderately regular bedding, and the usual hues both in weathered and unweathered strata; while the lowest exposed bed (4 or 5 feet thick) is made up of inter-laminated gray or white clay and orange or reddish loam, the clay being fine and plastic, the loam rather sandy and massive within each lamina, and the laminæ sensibly horizontal and ranging from an eighth of an inch to half an inch thick for the clay, and quarter of an inch to an inch or more for the loam. Both of these exceptional aspects of the formation are exhibited in various exposures in this region; both resemble in some measure characteristic aspects of the Potomac formation seen in eastern Virginia; and it is significant that the Potomac is not found here (probably by reason of removal through degradation), that crystalline rocks approach and in the immediate vicinity reach the surface, and so that the Appomattox probably rests immediately upon the eastward extension of the ancient Piedmont crystallines.

Nearer the coast the formation is frequently exposed in railway cuttings and displays the features characteristic of the contemporaneous deposits north of the Roanoke, save that the orange tints are less pronounced and mixed with browns and grays in some strata, that the bedding is thinner and more pronounced, and that pebbles are small and rare. It is significant that the aspect of the formation here approaches that displayed by the phosphate-bearing Pliocene beds of the South Carolina coast.

Another distinctive but hardly distinct aspect of the formation is extensively displayed in central South Carolina, notably about Columbia. Here the usual moderately regular and rather heavy but always inconspicuous bedding of the formation is displayed; but the prevailing colors are richer and darker than in other parts of the terrane, commonly ranging from orange red to chocolate brown. Moreover certain of the strata exhibit a peculiar mottling (which is better displayed farther southward); certain other strata exhibit a distinctive cross stratification defined by gray or white plastic clay in laminæ, irregular sheets, and lines of pellets; the various strata are more uniform in composition than in the north, consisting rather of loam than of sand and clay in alternating beds; and the deposit as a whole takes on a solid, massive, and rock-like appearance, and gives origin to a distinctive topography. So conspicuously diverse in color, texture, and habit of erosion are the prevailing formations of central South Carolina that over thousands of square miles the surface is popularly divided into "red hills" and "sand hills"—the former representing the Appomattox, and the latter the southern interfluvial phase of the Columbia formation. The distribution of pebbles in this vicinity is especially interesting: Northeast of the Congaree river on the line of the Richmond and Danville railway, pebbles are rare to within two miles of the present waterway; there they suddenly increase in abundance, and in some sections within a mile from the river form a considerable and sometimes the principal part of the deposit; while south of the river they quickly become rare, being abundant only within a mile or less of the river bluffs. The pebbles are predominantly of quartz though partly of quartzite, and comprise a few gneissoid fragments. They range in size from two and a half inches downward. Commonly they are accumulated in lines or pockets, sometimes at the base of the formation; but a few also occur disseminated throughout the ill-defined strata.

About the fall-line on the Santee river system, the Appomattox loam is in part overlain unconformably by the Columbia formation, though it has been severely degraded; and in an admirable section on the Richmond and Danville railway immediately east of the State House, where both upper and lower contacts are displayed, the Appomattox rests unconformably on the Potomac. Further up-river the Appomattox rests directly upon the Piedmont crystallines which here give origin to residuary products of dark red and brown color; and so the origin of the exceptionally rich hues of the formation in this region are not difficult to trace.

Is is in Georgia that the formation appears to be best developed: About the fall-line it stretches from the Savannah to the Chattahoochee in practically unbroken continuity; at many points it overlaps far upon the Piedmont crystallines; on the seaward side of the fall-line it is unquestionably overlapped in turn by the pine clad sands of the Columbia formation over many thousand square miles; it evidently reaches a considerable thickness—perhaps 100 feet or more; and its various features are in part intermediate between and in part common with those displayed by the formation in the Atlantic and Gulf slopes respectively. Moreover it exhibits in this region certain significant features not known elsewhere.

About Augusta, the exposures resemble those of the Congaree, save that the exceptionally rich hues have faded to the usual orange and orange-red; while the cross-stratification marked by lines of clay has become more, and the horizontal bedding even less, conspicuous. There is an excellent exposure of the gravelly loam of the formation at Green's Cut, south of Augusta, on the Georgia Central railroad. It is made up at this point of moderately homogeneous loam with little indication of bedding save that the abundant pebbles are commonly arranged in lines or accumulated in pockets, though sometimes disseminated. Twenty miles farther southward, near Munnerlyn, there is an exposure of 25 feet in which the loam is not only definitely bedded but divided by intercalated layers of sand and silt, giving an appearance of regular and distinct stratification; pebbles being small and rare, while the characteristic orange tints run into dull browns and grays. There is a similar exposure at Sun Hill, sixty miles east of Macon, in which the strata are partially lithified, and the general aspect approaches that of the regularly stratified Tertiary deposits of greater antiquity found farther seaward.

At Macon the formation finds typical development. Above the reach of modern alluvium, and above the vaguely defined and poorly exposed "second bottoms" it forms the prevailing surface; and in every street and suburban road, in every storm-carved runnel and roadside gulley, and in every cutting of the seven railways radiating from the city, its materials are exposed; and the landscapes are toned by its pure orange, orange-yellow and orange-red tints, or the brick-reds assumed on oxidation. Here the stratification of the deposit is rather less definite and regular than usual, and in some limited exposures it is apparently massive. Here, too, the distinctive cross-bedding seen frequently in the south is characteristically displayed—some beds throughout their entire thickness, and nearly all beds in some part of their thickness or length of exposure, exhibit a rather vague cross-stratification rendered conspicuous under certain conditions of weathering by intercalated laminæ and lines of pellets of white or gray plastic clay. About Macon, too, there is well displayed a characteristic habit of erosion and weathering which is common throughout the south and occasionally seen in the north; i. e., the exposed and long weathered surface of the deposit takes on a more massive aspect than that of the fresh cutting, the structure lines fade, the rain-cut gullies are transformed into deep and smooth sided amphitheatres separated by broad, even-faced buttresses: the whole forming soft contours. At the same time the exterior portion of the deposit undergoes a slight cementation, and the surface takes on a sort of dull glaze. This peculiarity of weathering is difficult to intelligibly describe, impossible to clearly portray, and yet so characteristic as to be readily recognizable throughout the greater part of the vast field occupied by the formation. About Macon, as in other exposures near the fall-line and on considerable rivers, the formation abounds in small pebbles, arranged in lines, accumulated in pockets, or disseminated throughout the deposit. On the Oconee these pebbles are chiefly of quartz with many of quartzite, and are commonly well rounded or sub-angular; and it is noteworthy that they are similar in size, material and degree of wear to those found in the subjacent Potomac formation.

At Macon, as at Columbia, the Appomattox is intercalated between the Columbia and Potomac formations, the Piedmont crystallines being exposed beneath the latter in the vicinity. The Columbia is represented by poorly displayed "second bottoms" and by the sand plains into which the lowlands merge a few miles southeast of the city. These deposits are strongly unconformable to and readily distinguished from the distinctive loams of the Appomattox. The Potomac consists of exceptionally regularly stratified clays and sands, the latter locally containing arkose in considerable quantity, with well rounded pebbles in sheets or pockets and sometimes scattered throughout the mass. It is noteworthy that although the Appomattox and the Potomac are here, as elsewhere, strikingly unconformable, they sometimes merge so completely that no line of demarkation can be drawn with precision. This is frequently the case when the Potomac consists predominantly of sand; when the uppermost stratum consists of clay the contact is usually distinct and sometimes quite conspicuous. In the exposures along the southwestern extension of Fourth avenue the Appomattox and Potomac commonly blend; in the cutting on the Georgia Central railway at the crossing of Oglethorpe street, the formations are readily distinguishable; while in the railway cutting four blocks farther southward the contact is distinct in one part of the section, though the deposits appear to merge in another part.

The finest southern exposures of the three formations so conspicuous and significant in the Middle Atlantic slope are found just below the falls of the Chattahoochee in the villages of Girard and Lively, Alabama, opposite Columbus. As usual there is great unconformity between the "second bottom" loams (by which the Columbia is here represented) and the Appomattox, the latter having been completely removed from a considerable belt flanking the river, while the former rests upon the gneiss and the Potomac arkose throughout a large part of this belt. An analogous relation holds between the Appomattox and the Potomac—an immense volume of the latter having been carried away before the former was laid down.

The characteristics of the Appomattox in this vicinity are normal, save that the distinctive cross-bedding outlined in laminæ of clay or lines of pellets of the same material is exceptionally conspicuous, that the pebbles are larger, more abundant, and rather less worn than usual, and that there is a notable element of arkose in its composition. In explanation of these slight divergences from the type it should be noted that the Potomac in this locality consists in exceptionally large part of arkose (great beds of it sometimes being scarcely distinguishable from the disintegrated gneiss magnificently displayed immediately below the lower dam), that certain layers of it consist of exceptionally pure kaolin-like clay, and that its pebbles are larger and less worn than those found upon smaller rivers—or in short, that the local features of the Potomac are reflected in those of the Appomattox. Contacts between the Appomattox and the Potomac are clearly displayed in the railway cutting in Lively, and in a natural gulley half a mile northwest of this point; in the former exposure the formations are distinct throughout the greater part of the exposure, but inseparable with any degree of accuracy in another part; while in the second exposure the regularly bedded orange-brown loams of the Appomattox, with a pebble bed at the base, are conspicuously demarked from the creamy-white, cross-stratified arkose of the Potomac. The best exposures of the Appomattox occur in the scarp of a fairly well defined terrace about a hundred feet above the low-water level of the river (below the falls) in the village of Girard.

Eminently satisfactory exposures of the Appomattox occur about Montgomery (particularly in cuttings on the M. & E. railway in the southeastern part of the city), where it rests unconformably upon the Eutaw sands, the junction being sometimes marked by a ferruginous crust, again by a sheet of pebbles, and elsewhere by a decided difference in hue, though it is sometimes indistinct; but the characters of the formation here are in no way specially noteworthy save that the pebbles contain an exceptionally large element of quartzite or semi-quartzitic sandstone, together with large numbers of subangular fragments of chert and siliceous dolomite.

The numerous excellent exposures of the formation about Tuscaloosa are noteworthy in that they form a definite terrace, evidently of considerable antiquity though probably restored in part during the Columbia epoch, upon which the city as well as the State University and Insane Hospital are located. They are also noteworthy in that the pebbles comprise cherts, siliceous dolomites, and a rather unimportant element of quartzite, but no true crystallines. The pebbles are notably smaller and less worn than in the more easterly and northerly localities. Here as elsewhere about the fall-line the formation is overlain unconformably by the Columbia, and in turn overlies with still greater unconformity the Potomac—the Tuscaloosa formation of Smith and Johnson; yet here as in other localities these formations of widely diverse age sometimes merge so completely that no sharp line of demarkation may be drawn between them. This is notably the case in the railway cutting at Cottondale, seven miles east of Tuscaloosa, where the Potomac is a cross-stratified gravel with a matrix of sand, and the Appomattox a horizontally bedded mass of similar gravel in a matrix of loam; yet usually despite this discordant bedding, the materials merge. In some of the cuttings on the A. G. S. railway between Cottondale and Tuscaloosa, however, the junction is marked either by ferruginous crusts or by sheets of pebbles of ferruginous sandstone evidently derived from the older formation.

Farther southward the formation is displayed at several localities, notably at Eutaw. Here it diverges from the usual character in two respects, each of which indicates an intimate relation to a subjacent and much older formation: north and east of Eutaw the deposit is exceptionally sandy and friable and the bedding is frequently obscure; and in numerous exposures on the A. G. S. railway and along the wagon road between Eutaw and the Tuscaloosa or Warrior river it may be seen to merge into the stratified sands of the Eutaw, and in general to take on the features of that Cretaceous formation;—in short it is as evident here that the Appomattox is made up in part of the immediately subjacent formation as it is in the numerous contacts with the Potomac (Tuscaloosa) formation at Lively, Macon, Columbia, and other points at which the materials obviously intergraduate. Southwest of Eutaw a change in the composition and general behavior of the deposit quickly supervenes; only scattered ridges and irregular patches of the formation now remain overlying the peculiar middle Cretaceous formation which Smith and Johnson now designate the Tombigbee chalk (the "Rotten Limestone" of the books); in these outliers the deposit exhibits the usual characteristic features of the deposit; but on close examination the sands and clays of which it elsewhere consists are found to be intermixed with calcareous particles, while toward the surfaces it loses the peculiar massive aspect and dull glaze so commonly characteristic of the formation, and commonly breaks down into sandy red clays. Over the Tombigbee chalk in this vicinity the prevailing colors are lighter and grayer, and over the Eutaw sands darker and browner, than those displayed toward the fall-line or generally elsewhere.

It is in Alabama that the Appomattox formation has been found nearest the coast: between St. Elmo and Grand Bay, in the extreme southwestern corner of the state, two strongly contrasted types of surface appear. The first comprises the smooth, sensibly horizontal pine-clad sands or "pine meadows" of the coast; and the second consists of undulating bosses, knolls, and plateaus rising above and evidently protruding through the sand. The sand plains and pine meadows represent the local phase of the Columbia formation; while the protruding knolls and plateaus of ancient topography consist of regularly and rather heavily bedded loams, sands, and clays, commonly orange-hued but weathering to dark reds and browns, and evidently represent a somewhat erratic phase of the Appomattox. The deposits are erratic, *first*, in the complete assortment of materials, the sands and clays being separated and laid down in alterating layers; *second*, in the fineness of the materials, clay forming the predominant element and the pebbles being represented only by bits of quartzite or chert seldom over a quarter of an inch in diameter sparsely disseminated through the sandy layers; *third*, in the exceptionally regular stratification; and *fourth*, in the absence of the distinctive clay-outlined cross stratification—though the sandy strata are sometimes cross bedded. The formation here is exceptionally ferruginous. A thin layer in a cutting three-quarters of a mile east of Grand Bay is locally used as an ochre; the plowed fields and other exposed surfaces are sometimes besprinkled or even shingled with small ferruginous nodules (or "buckshot") weathered out of the loam; the prevailing colors are harsher and generally darker than usual (though not so dark as at Columbia), ranging from orange-yellow mixed with gray in some strata, to prevailing orange-reds weathering to brick-reds and chocolate-browns; and the peculiar mottling characteristic of the deposit under certain conditions of exposure throughout nearly its whole extent is beautifully displayed. In the railway section in the eastern part of Grand Bay the relation between the mottling below the reach of ready oxidation and the formation of the ferruginous concretions found on the surface are clearly shown: the lower part of the exposure, extending to within 10 or 12 feet of the surface, is of fairly uniform orange or orange-yellow hue, with some strata passing into gray; next follows a stratum of 5 or 6 feet, concentric with the surface and discordant with the stratification, in which the uniform hues are shot with vertical or oblique lines of darker color, increasing in number upward and finally uniting in a network of orange-red bands an inch or more in width enmeshing polygons and irregular figures of original color one to five inches in diameter; while still nearer the surface the bands widen, the lighter colored polygons disappear, and a nearly uniform orange-red hue supervenes. Yet some of the lines of darker color persist as narrow bands of brown, perhaps marking jointage planes; and on closely approaching the surface these are frequently found to become partially indurated, so as to form a network of embossed chocolate-brown lines, enmeshing orange-red polygons. About the points of union of the embossed brown bands the segregation of ferruginous matter and the cementation are most decided; and quite near to the surface the nuclei thus formed may be found to graduate into irregular ferruginous nodules, diminishing in size and increasing in hardness until they pass gradually into the state exhibited by the surface-found concretions. So the mottling, the darkening of hue, the general ferrugination, and the formation of nodules are simple results of oxidation and hydration produced by weathering.

In Mississippi the Appomattox is well displayed at Nicholson, near Pearl river, and only 20 miles from the Gulf; and 10 miles farther northward, at Highland, there is a still better development in which there is so large an element of pebbles that the deposit has been extensively worked as a source of gravel for railway ballasting. At these localities the formation exhibits the usual characteristics, save that in the first pebbles are small and rare. In the second locality the abundant pebbles consist predominantly of sub-angular fragments of chert an inch and a half or less in diameter, with no representatives either of the quartz and quartzite of the northeast, or of the siliceous dolomite found at Tuscaloosa. At Hattiesburg the formation is exposed in the uplands overlooking Leaf river, and about Ellisville it crosses the divide between that river and the Tallahoma, the usual characteristics being displayed in both localities; at Vossburg there is an extensive accumulation of the deposit, which is here fairly stratified and exceptionally friable, on the divide between the Leaf and Chickasawhay drainage basins; and at Brandon the exposures are less extensive than but similar to those at Vossburg.

In the vicinity of Meridian there are numerous exposures, some of which are erratic in character: Over the ridge formed by the peculiar siliceous rocks of Eocene age called by Smith the Choctaw buhrstone, the Appomattox is uncommonly obdurate, and the distinct cross-bedding is outlined in fine sand rather than in clay: yet despite the uncommon obduracy of the material it has been completely removed from the greater part of the surface throughout much of this belt of high relief. On the northeastern side of the isolated knob of Buhrstone a mile south of Meridian there is a bed of brown or orange-red sand corresponding in many respects with, and probably justly referable to, the Appomattox, though the usual heavy bedding is absent, the characteristic cross-bedding is inconspicuous, and the mass is much more friable than usual. On the lowlying lands three miles northeast of Meridian the Appomattox generally forms the surface; but it here contains an exceptional element of clay, and in many sections appears to merge into the Eocene clays assigned to the Hatchetigbee formation by Smith and Johnson, just as another phase merges into the Potomac (Tuscaloosa) in another locality.

So the Appomattox formation may be briefly described as a series of obscurely stratified and frequently cross-bedded loams, clays, and sands of prevailing orange hues, with local accumulations of gravel about waterways; the materials varying somewhat from place to place, but always in the direction of community of material between the formation and the older deposits upon which it lies; while as a whole the deposit retains so distinctive and strongly individualized characteristics as to be readily recognized wherever seen.

GEOGRAPHIC DISTRIBUTION.

The areal distribution of the Appomattox formation may be stated either simply and easily in terms of original deposition, or in greater detail and with more difficulty in terms of present outcrops.

In general distribution, the formation is known to expand and thicken southward from a few thin beds occupying a narrow belt on Potomac creek, a few miles north of the Rappahannock, to a thick deposit forming a terrane forty or fifty miles wide on the Roanoke; to extend thence southward, in a broad zone at first widening but afterward narrowing with the encroachment of the overlapping coast sands upon its area, quite across the Carolinas; to form the most conspicuous terrane of central Georgia, where it stretches from the fall-line to the inland margin of the coast sands all the way from the Savannah to the Chattahoochee; to again expand greatly in Alabama with the contraction of the overlying coast sands until it forms an essentially continuous terrane stretching from the fall-line at Montgomery and Tuscaloosa to within half a dozen miles of the Gulf in the southwestern corner of the state; and to maintain this enormous width in Mississippi, where it extends southward from the Paleozoic area in the extreme northeastern corner of the state to within twenty miles of the Gulf on Pearl River and westward to within fifty miles of the Mississippi, to be in part overlain and in part replaced by the local phases of the more recent Columbia formation developed on Gulf and river. This field of fully 50,000 square miles is that over which the Appomattox has been traced in thousands of exposures, and in which it generally forms the prevailing terrane.

If the direct observation be supplemented by legitimate and necessary inference, the formation must be so extended as to bridge the valleys from which it has been degraded, and to stretch beneath the various phases of the Columbia formation well toward the Atlantic and Gulf coasts—though its seaward extension is doubtless aberrant in composition and structure, particularly in Florida, where it merges with the continuous series of off-shore deposits of the Neozoic which combine to form the great submarine shelf fringing the continent on the east and south. With this legitimate extension, the field of the formation becomes essentially coëxtensive with the Coastal Plain of the Atlantic and Eastern Gulf slopes (exclusive of a part of Florida) and assumes an area of 250,000 or 300,000 square miles. Over the whole of this vast area the Appomattox formation must have stretched; and over the greater part of this area it must maintain the wonderfully uniform characteristics of composition and structure exhibited to-day by its stream-carved remnants.

The areal distribution of the remnants of the Appomattox ormation represented by present exposures cannot be set forth n detail without large scale maps or more elaborate statement han space will now permit; but certain features of local disribution are too significant to be neglected.

Throughout the Coastal Plain the formation is deeply disected if not completely divided by the larger rivers at and ommonly for long distances below its inland margin. The ibutaries have invaded it as well, and so too have the smaller reams, down to the rivulet and storm-filled rill; and thus its ntire surface has been sculptured by running water in a maner well illustrating the type of configuration elsewhere assed as autogenetic. Now many of the tributaries, as well some of the subordinate members of the wide branching rainage systems, have, like the principal rivers, cut comletely through the formation and exposed the sub-terrane ver considerable areas; and while the extent of the destrucon of the formation in this manner is of course dependent pon the local efficiency of the several factors of degradation eclivity, stream-volume, texture of the rock mass, etc.), it is vidently related in some degree to the character of the subterane. This relation is well exemplified over the uplands anking the Tombigbee and Alabama rivers on the west. ver the terrane of the Potomac formation the Appomatox generally prevails, despite the considerable altitude and igh local relief, save in the valleys of the largest rivers; over he less elevated terrane of the Eutaw sands, it is more freuently and more widely cleft by drainage ways, and its emnants are thinner; over the next newer formation (the Tombigbee chalk) which lies low and flat, the greater part of he Appomattox has been carried away, not only in the vicinity of the Tombigbee river but all the way from northeastern Mississippi to beyond the Alabama river, so that it is commonly represented only by isolated belts and irregular patches which, as Smith has shown, most frequently lie on northerly slopes; over the terrane of the Eufala sands, in which the local relief again increases, the remnants of the Appomattox quickly increase in number and expand until the formation once more forms the prevailing surface on the uplands, though the Cretaceous deposits are laid bare along most streams and form the prevailing lowlands; and over the eight or nine lower Eocene formations into which the Lignitic of Hilgard has been divided by Smith and Johnson, and among which clay is the predominant material, the Appomattox still further expands until it forms almost the entire surface, highland and lowland alike, save in the valleys of the larger rivers. Still farther southward lies the great siliceous deposit of the middle Eocene commonly known as Buhrstone—the Choctaw buhrstone of Smith; its rocks are the most obdurate of the entire Neozoic series within the Gulf slope, and so its general surface is elevated and sculptured into a complex configuration of pronounced relief and sharp contours; yet despite these conditions so exceptionally favorable to degradation, the Appomattox frequently maintains its integrity over considerable areas. Beyond the hill-land of the buhrstone lies the lowland formed by the predominantly calcareous newer Eocene formations—the Claiborne, Jackson and Vicksburg—over which the Appomattox is again trenched by almost every waterway and reduced to ragged remnants only more extensive than those overlying the Tombigbee chalk; but upon the silico-argillaceous terrane of the Grand Gulf the remnants once more expand until they form the greater part of the surface, save along the larger waterways, as about Hattiesburg in Central Mississippi. In short, the formation is generally preserved over loamy and clayey terranes, much more seriously invaded by erosion over sandy terranes, and largely degraded over calcareous terranes; and this is true not only of the section from Tuscaloosa to Hattiesburg in Alabama and Mississippi, but of the formation as a whole.

It has already been intimated that the composition of the Appomattox everywhere depends in part upon that of the subterrane, i. e., that its materials everywhere consist of local elements and erratic elements combined in varying proportions; and the variable friability and solubility resulting from this inequality in composition is evidently the reason for the unequal resistance which the formation has offered to degradation in various parts of its extent.

HYPSOGRAPHIC DISTRIBUTION.

The best development of the formation in Virginia and North Carolina lies between 25 and 150 feet, and its upper limit is probably less than 250 feet, above tide. Farther southward the lower observed limit remains about the same, while the upper rises to at least 650 feet over the divide between the Congaree and Savannah, where the formation is well developed and constitutes the prevailing surface. The lowest altitudes at which it has been observed near the Gulf are less than 25 feet above tide at Nicholson and not much higher at Grand Bay; and the greater altitudes in the Gulf slope are not less than 450 feet in uplands near Tuscaloosa, and 600 feet in the Buhrstone hill-lands west of Meridian.*

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* It has recently been found washed by tide waters on the east side of Mobile bay, by Mr. L. C. Johnson.

Briefly, the hypsographic distribution of the Appomattox ormation is essentially identical with that of the general surace of the Coastal Plain from the Potomac to the Pearl, save hat the formation extends a little farther inland than the nass of the Neozoics, overlapping for a few miles of distance nd a few yards of altitude upon the Piedmont crystallines vithin the fall-line.

STRATIGRAPHIC RELATIONS.

In several exposures on the Appomattox river at and below Petersburg, the fluvial phase of the Columbia formation (as leveloped in the Middle Atlantic slope) rests unconformably n the surface of the Appomattox, and a like relation to the nter-fluvial phase is displayed in several railway cuttings outh of Petersburg. In the excellent section at Columbia he coast sand phase of the Pleistocene formation rests unconformably upon the Appomattox; and at Lively, Alabama, the "second bottom" phase of the newer formation overlaps unconformably an eroded surface of the older one. From these exposures in section the two formations are known to be diverse in age.

The unconformity between the Columbia and the Appomattox becomes more striking when the relations of the two formations to the larger rivers are considered: Every great waterway traversing the Coastal Plain from the fall-line to the shore of Ocean or Gulf has for scores of miles trenched the Appomattox to its base and commonly cut far into older strata, and the orange loams and sands are usually removed from the bottom and half the sides of the trough whose axis is marked by the waterway; while the same rivers are flanked by terraced belts of Columbia loam overlying the degraded edges of the Appomattox and the older strata alike, and little invaded by erosion (except on the Savannah and the Congaree) save that of the river channel. It is true that the Chattahoochee, Tuscaloosa or Warrior, and some other rivers are locally flanked by terraces of Appomattox materials; but these terraces appear to be the product of local wave work during the Columbia submergence rather than of the rivers and waves of the Appomattox period.

Still more striking does the unconformity appear when the general configuration of the two formations is compared: About Grand Bay and St. Elmo in southwestern Alabama the Columbia forms a smooth, monotonous, sensibly horizontal plain, while the knolls and uplands of Appomattox protruding through the flat-lying sands exhibit well developed autogenetic sculpture; over the smooth plains of the Tombigbee chalk the Columbia deposits skirt the rivers in sharp-cut terraces, while the Appomattox has been largely removed by erosion; on the Oconee and Ogeechee Rivers in eastern-central Georgia the monotonous plains formed by the coast sands of the Columbia encroach upon and send tongues and fingers into the ravines and broader depressions of a boldly sculptured upland of Appomattox loam; and in North Carolina and Virginia the Columbia is little more than a flowing mantle masking the more rugged framework of the older Appomattox. Indeed, throughout their extent these formations illustrate the contrast between "topographic youth" and "topographic old age" as defined by Chamberlin—the one is soft-faced, smooth, nearly featureless; the other hard-visaged, furrowed, strong featured.

Local unconformities between the Appomattox and the several subjacent Neozoic formations are frequently exposed in section; and general unconformity with all these formations alike is indicated by its overlap upon all from the Grand Gulf of the Miocene to the Potomac (Tuscaloosa) of the Cretaceous or Jurassic.

Especially significant is the unconformity between the Appomattox and the Grand Gulf—the youngest of the series: In southern Mississippi generally, and notably in the vicinity of the Tallahoma river about Ellisville, there are sufficiently numerous exposures of the siliceous clays constituting the Grand Gulf to show that the surface of the terrane is one of autogenetic sculpture, that the Appomattox was laid down as a continuous mantle upon this sculptured surface, and that after the close of the Appomattox period the rivers resumed approximately their ancient courses and have impressed a new and fairly consistent sculpture upon the old. So, while the newer formation crowns eminences and floors depressions alike where not profoundly eroded, its mass is little if any thicker on the upland than in the valley, and exposures are as common in the upper as in the lower slopes; and along the larger rivers the Appomattox has been frequently removed from the lower slopes while it yet crowns the divides and highlands quite to the brows of the bluffs.

Especially significant, too, is the relation between the Appomattox and the obdurate strata of the Choctaw buhrstone, since a rough record of great continental oscillation is contained therein: Southwest of Meridian and west of Corinne lies a prominent ridge of the peculiar siliceous rocks of this formation, making the divide between the Okatibbee and Chunkee river. This divide is a meandering crest, sending out lateral spurs and culminating in height at every bend, separating a plexus of steep sided ravines, coves and amphitheaters—the whole simulating a mountain crest-line with its peaks, arêtes, cols, gorges and amphitheaters, save that every summit is blunted. This striking configuration tells a significant story, but one too long for repetition here—it suffices that it tells of a time when the land stood higher and the rivers were made more energetic than to-day. Now over this irregular surface the Appomattox was evidently spread mantlewise, just as over the qualitatively similar though less strikingly emphasized surface of the Grand Gulf; and here as there the post-Appomattox rivers sought their old courses, and the new drainage system corresponds substantially with the old;* but the lower base level of to-day has tended to develop a flatter surface than the old, and while remnants of the orange loam are frequently caught on the crests and lodged in the amphitheaters, they have been commonly removed from the higher altitudes and are generally confined to the lower levels.

Perhaps the Appomattox merges into the phosphate-bearing Pliocene beds of South Carolina; probably it is continuous with some of the newer off-shore deposits of Florida; unquestionably it represents but the landward portion of one of a vast series of deposits which at some distance beyond the present shores of Ocean and Gulf are unbroken; but certainly there is a great unconformity, first between the Pleistocene Columbia and the Appomattox, and second between the Appomattox and all of the subjacent Neozoic formations yet satisfactorily discriminated within the Atlantic and Gulf Slopes.

TAXONOMY.

No fossils have thus far been found in the Appomattox formation except at Meridian, where Johnson has found it to contain well preserved magnolia leaves apparently identical with those of trees now growing in the same vicinity. Its stratigraphic position, unconformably below the Pleistocene and unconformably above the (probably) Miocene Grand Gulf formation, indicates an age corresponding at least roughly with the Pliocene.

The formation represents a considerable part of a more or less vaguely defined series of deposits variously called "Orange Sand," "Drift" or "Quaternary," "Southern Drift," etc., by many geologists; but since this vaguely defined series included

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*The history of renewal of buried drainage systems in the eastern Gulf slope is recorded in wonderful fulness and clearness. Three and even four times has the autogenetically sculptured surface of the Choctaw buhrstone been submerged and mantled with sediments, only to rise and resume more or less fully its old aspect under the influence of waterways following the old lines. Such resurrected, or *palingenetic*, drainage and sculpture is characteristic of much of Mississippi.

not only the Appomattox but also the basal gravel beds of the Pleistocene loess, parts at least of the Cretaceous or Jurassic Potomac (Tuscaloosa) formation, and other deposits of various ages, none of the old designations can be retained without material modification in definition. It therefore seems wise to extend the term applied to the formation in the region in which it was first studied and clearly defined.

SOURCES OF MATERIALS.

The materials of the formation which may be certainly traced to their sources are (1) pebbles or gravel, (2) arkose, and (3) a certain portion of the more finely divided matter.

It has been stated incidentally that about the fall-line the pebbles of the Appomattox are in large part identical with those of the Potomac, and that they are evidently derived therefrom. It has also been stated incidentally that the pebbles of both Appomattox and Potomac vary from river to river —quartz on the Rappahannock, quartzite with less quartz on the James and Appomattox, quartz with less quartzite on the Roanoke, quartz mainly on the Neuse and Cape Fear, quartz with less quartzite on the Santee system, quartz and quartzite in nearly equal proportions on the Savannah and Ocmulgee, quartzite with less quartz on the Chattahoochee, quartzite, siliceous dolomite, quartz, and chert (in order of abundance) on the Alabama, siliceous dolomite, chert, and quartzite on the Tuscaloosa (or Warrior), and chert on the Pascagoula and Pearl; and this variation goes exactly with the petrographic character of the most obdurate rocks traversed by the upper reaches of the respective rivers.

Arkose is but a limited and unusual constituent of the formation, and is only known to occur under two sets of conditions: It occurs when the formation rests directly upon crystalline rocks or when these rocks are exposed in such proximity as to indicate absence of deposits intermediate in age, as at Wilson, N. C. It occurs also, in less abundance and purity, where the Appomattox rests directly upon the Potomac formation and the latter is made up largely or exclusively of the same material, as at Girard, Alabama. In both cases the material is evidently derived from an adjacent and older formation.

Certain striking features in geographic distribution of the Appomattox formation already pointed out indicate that in many if not in all cases a part of its materials were derived from immediately subjacent strata, and so that the character of this formation in a measure reflects that of the sub-terrane— the characteristic orange loams being exceptionally loamy over loams, exceptionally sandy over sands, exceptionally argillaceous over clays, and exceptionally calcareous over limestones.

The combined volume of pebbles and gravel, arkose, and the local elements of finely divided material, however, constitute but the smaller portion of the entire bulk of the formation; and the general similarity in composition of the formation with the residuary loams and clays both of the Piedmont crystallines and of the Paleozoics of the Gulf slope suggests that these residua contributed largely to the formation. This suggestion gains strength from the phenomena exhibited at Columbia, where the Appomattox takes on a local aspect corresponding precisely with the local aspect of the residua derived from the neighboring crystalline rocks.

INTERPRETATION.

The Appomattox formation illustrates a method of geologic correlation which has grown out of the work in the Coastal Plain of eastern America, and which is deemed worthy of statement.

The primitive method of geologic correlation depends upon tracing actual stratigraphic continuity across or around intervening areas. This method is to-day the simplest and safest within the reach of geologists; but it is practicable only within single geologic provinces, and is limited by many other conditions.

Another method of geologic correlation is based upon petrography. At certain stages in the development of the science of the earth, the various classes of rocks have been more or less widely correlated upon grounds of similarity in composition, texture, structure and other petrographic characters; but it is now generally recognized that these characters are simply the expression of processes and conditions which have been repeated in many parts of the world and in all periods, and thus that the method can only be applied cautiously and within narrow limits. To-day, correlation by petrography is practically confined to the ancient crystalline rocks, and even here it is viewed with distrust by leading American students.

The disciples of William Smith—who are as numerous to-day as the devotees of geology—correlate groups of rocks by paleontology. It is the strength of this method of correlation that, as practically applied, it embraces the desirable features of the more primitive methods; that it involves also a broader and more comprehensive grasp of phenomena and principles than the simpler methods out of which it was developed; that it rests upon a sound philosophic basis; and that it unites the physical aspect of geology with the record of biotic development upon the earth in such manner as to form a logical and consistent basis for the current cosmogony of enlightened men. It is the weakness of the method that many rocks are too poor in fossils to be correlated thereby; that formations may be homotaxial yet not contemporaneous and *vice versa;* that fossil facies represent the product of two principal factors of which one (environment) is so variable under local conditions that the product is inconstant among the minor rock divisions; and that the geologic chronometers afforded by fossil plants, fossil invertebrates and fossil vertebrates respectively give unlike time units and, sometimes, discordant readings. To-day the larger groups are confidently correlated by paleontology; but leading American geologists no longer accept identity of fossil facies as final proof of equivalence among the minor rock divisions.

The method of correlation devised to systemize the structure of the Coastal Plain combines the desirable features of the older methods, and adds thereto the interpretation of the products of the several physical processes operating upon the earth's exterior. It is a correlation by community of genesis, or *homogeny.* The method involves a yet broader conspectus of phenomena and principles than the paleontologic method; for in its application it is necessary to mentally restore the various physical and biotic conditions of the past, just as paleontology vivifies the fossils of past ages.

Correlation by homogeny is a simple application of the well known principles (1) that geologic processes may be inferred from their products, and (2) that geologic processes are universally interrelated.

Since the birth of the science it has been the proximate end of geology to ascertain the genesis of terrestrial phenomena, with a view to the ultimate end of developing a rational and valid cosmogony; and great progress has been made in this direction. Now, "scientific progress may be measured by advance in the classification of phenomena. The primitive classification is based on external appearances, and is a classification by analogies; a higher classification is based on internal as well as external characters, and is a classification by homologies; but the ultimate classification expresses the relations of the phenomena classified to all other known phenomena, and is commonly a classification by genesis." So, the primary geologic classification was based directly upon the objective phenomena of the external earth, and early geologic literature was pervaded and the science shaped by this fundamental idea. As time went on this classification was found too narrow to represent intelligibly the facts and their relations, and the desire for a more comprehensive taxonomy was indicated by semi-arbitrary division of the science into departments defined by community of agencies (physical geology, structural geology, historical geology, etc.), within which the minor classes were variously defined and grouped. Still later, not only the primary but the secondary categories of phenomena came to be commonly defined by genesis; and to-day the taxonomy adopted by leading American geologists is predominantly genetic, and geologic research is considered incomplete if it fails to indicate the origin and course of development of the phenomena studied.

The interrelation of geologic processes is illustrated in terrestrial gradation—the matter degraded from one spot or region is deposited in some other spot or region; and commonly the regions of degradation and deposition are contiguous. It is also illustrated in the deformation of the terrestrial crust, whether antecedent or consequent*—when one part of the terrestrial crust is heaved another part is thrown; and commonly the heaved and thrown parts are contiguous. It is illustrated moreover in the relations between deformation and gradation—when a mountain range or a continent is lifted it is attacked by degradation, and when a sea bottom is formed it is subjected to deposition; and when degradation lightens the continent or mountain it is still further lifted, and when deposition loads the sea bottom it is still further depressed. This interrelation runs through the entire range of geologic processes. It follows that any process operating in one part of a geologic province must be represented by a similar or kindred process in other parts of the same province—i. e., in a mountain province the degradation of one part is represented by degradation (perhaps at different rates) in all parts; and in a sea province deposition in one part is represented by deposition (varying in rate and quality with local conditions) in all other parts. It equally follows that the products of the processes are genetically related—that the sculptured forms produced by degradation are of common genesis and greater or less similarity in form according to the local conditions, and that the deposited beds are of common genesis and greater or less similarity in volume and material according to the local conditions. It further follows that the sculptured forms on the one hand are genetically related to the deposited beds on the other hand; and it is indicated not only by theory but by observation that such relations sometimes extend not only from land province to sea province, or *vice versa*, but across a sea province from one to the other of the land provinces by which it is bounded, or *vice versa*, and thus throughout great areas and perhaps continents. In short, it is evident that when geologic agency was at work in any spot it must have been doing something throughout the neighborhood; and properly conducted field work commonly shows what this something was.

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* The various mass movements concerned in the development of continents and mountains are conveniently grouped as *deformation*, and the various classes of particle movements concerned in the transfer of materials upon the surface by air, water, ice, and other agencies are conveniently grouped as *gradation*; the earth movements concerned in the elevation and exposure to degradation of continents are conveniently classed as *antecedent*; and the earth movements resulting from transfer of materials through the processes of gradation are conveniently classed as *consequent*.—Cf., Nat. Geog. Mag., vol. i, 1888, pp. 27-36; Geol. Mag. Decade III, vol. iii, 1888, pp. 489-495.

Now the universal interrelation of geologic processes has been constantly recognized in the researches into the genesis (1) of the deposits forming the Coastal Plain and (2) of the correlative sculptured forms found in the contiguous Piedmont and Appalachian regions; and it has been ascertained that each category of phenomena commonly represents two classes of genetic conditions—one general and the other local. Thus the topography of the Piedmont and Appalachian regions gives a record of a certain elevation above base level during each of three or four well defined periods, as a general condition whose effects may be traced over immense areas; but it also gives a record of local conditions varying from place to place with the volume and declivity of streams, the obduracy of the rocks, the strike and dip of the strata, the homogeneity or heterogeneity of the terranes, etc. Thus, too, the sedimentary formations of the Coastal Plain give a record of submergence beneath the ocean, during each of several well defined periods, as a general condition affecting immense areas; but they also give records of local conditions varying from place to place with the proximity to and volume of rivers, the exposure to prevailing winds, waves, and currents, the depth of submergence, the proximity to shores, etc. But the effects of the general and local conditions respectively can commonly be discriminated with confidence, and the products of the general conditions traced throughout their extent. This is true specifically of the littoral and marine formations of the Coastal Plain, all of which represent widespread submergence with local variations in depth of water, proximity to shores, activity of deposition, vicinity of rivers, activity of waves, etc. The Coastal Plain formations may therefore vary from place to place in composition, texture, and structure; but the different phases are intergradnating parts of an indivisible unit, the local variations are repeated from place to place, and the attitude of each formation indicates a like relation between sea and land in all parts.

In discriminating the general and local genetic conditions, it is necessary to ascertain the relations between each formation and its newer and older neighbors, and to interpret the record of each unconformity in terms of continent growth. By this means the different parts of a formation may be found to represent not only general community of genesis but community of beginning and ending—in short entire community of structural relation. Each part of the formation then records in similar terms the same episode in continent-building and world-growth.

So, when a Coastal Plain formation is found to represent general community of genesis and structural relation in its various parts it is considered homogenic and accepted as a record of an episode in geologic history. The parts may or may not be homotaxial; one part may be slightly older than another part; but in a general way it is contemporaneous throughout. Homogeny implies not only equivalence but synchrony.

The value of homogenic correlation is illustrated by the Columbia formation: in the Middle Atlantic Slope the formation consists of two diverse phases, one of which is composed of dissimilar parts; in the Southern Atlantic and Eastern Gulf slopes the brick clays, bowlder beds, and veneers of local debris of the north are replaced by the "second bottoms" and coast sands; and in the Mississippi embayment the formation is represented by the stratified clays, silts, and sands of the Port Hudson, and the strongly individualized loess with its basal gravel beds. Yet these widely diverse deposits represent a general condition of submergence varying in amount from region to region, in a gradual manner; the basal unconformities are alike, and represent like conditions of continent-growth; and the degradation suffered by the formation in its various parts is indicative of like antiquity. Again, one local phase found in the Middle Atlantic Slope tells of local activity of the rivers, the other tells of a general activity of estuarine waves and currents, and both tell of glacial cold; the testimony of glacial cold fails in the Southern Atlantic and Eastern Gulf slopes, but there one phase tells of river work and estuarine conditions, and another of wave work and marine conditions, both operating on a distinctive local formation. So, too, the loess and the subjacent gravel beds in the Mississippi embayment tell of glacial cold in the upper reaches of the river, accompanied first by a stimulated transportation and subsequently by such submergence as to slacken the waters and precipitate fine debris; while the Port Hudson clays, silts, and sands tell of submergence and estuarine deposition in the brackish waters of an arm of the Gulf. Thus the general condition represented by the deposit is everywhere the same; while the local variations may be ascribed to varying local conditions. The formation has indeed been connected stratigraphically between its most widely diverse phases and throughout a considerable part of its area; but the absolute identification of the various parts of a formation so diverse in composition, so vast in area, and so unequal in hypsographic distribution, is rendered possible and satisfactory only by the homogenic method of correlation.

The value of the method is still better illustrated by the Appomattox: This formation is frequently buried beneath newer deposits, and frequently and widely divided by erosion over large areas, so that connection of the exposures by stratigraphic continuity is impracticable. It is essentially unfossiliferous in the exposures thus far examined, so that paleontologic correlation is impracticable; and while its materials, texture and structure are moderately constant, they are too variable to warrant correlation by petrography alone. Yet it is evident that the various parts of the formation are littoral or sub-littoral; that all represent temporary incursion of the sea upon a long-sculptured land surface; that all are affected by the composition of the subterrane; that all are affected by the proximity of rivers flowing along the present water lines; that the materials everywhere comprise certain constant elements; and that the structural relations of the formation are essentially identical throughout its extent. So this formation, like the Columbia, tells of a uniform general condition and of certain easily discriminated local conditions; and its various parts may thus be confidently correlated by homogeny. The formation has indeed been traced and connected as far as possible by stratigraphic continuity through thousands of exposures; but the isolated knobs projecting through newer deposits and the isolated remnants left by erosion, and indeed the regional developments of the orange-hued deposit could never have been satisfactorily identified save by homogeny.

Eventually the formation will be confidently correlated with certain topographic stages displayed in the Piedmont and Appalachian regions of the Southern Atlantic and Eastern Gulf slopes; but this correlation remains for fuller development through future work.

It should be pointed out that neither the Columbia nor the Appomattox adequately illustrates the value of homogenic correlation, by reason of their poverty in fossils. Thus far paleontologic correlation has been based upon certain explicit or implicit assumptions concerning the geographic distribution of organisms and the relations between organisms and environment during past ages; i. e., it has been commonly assumed by paleontologists that the geographic distribution of organisms and their relations to environmental conditions in the past were much the same as those of the present. But when the geologic formations are correlated by the physical method, the geographic distribution of organisms and the relations between organisms and environment during the geologic periods may be determined with only less accuracy than the like conditions are determined to-day. So, by homogenic correlation, the ebb and flow in the many branches of the vital stream during long past eons will be measured, homotaxis will blend with homogeny, and the cosmogony which it is the province of geology to develop will be refined and ennobled.

By reason of its prevalence, its distinctive coloration, and its fairly homogeneous composition, the Appomattox formation is the most conspicuous deposit of the Coastal Plain between the Roanoke and the Mississippi; over much of this vast area it has been traced in thousands of exposures and extensively connected by stratigraphic continuity, yet the observations have been fully interpreted and the exposures finally correlated by homogeny; and it is largely through the application of this method of study that the formation has been found to be a well defined and indivisible structural unit, representing a single clearly defined episode in the development of the continent. So distinctive is the orange-hued loam, and so definite the history recorded within it, that it is destined to rank as a great datum formation, from which the stratigraphy and geologic history of the Coastal Plain must be reckoned downward and backward as they are reckoned upward and forward from the Potomac.

Hitherto no geologist has been able to form a definite conception of the physiography of the southeastern part of the continent during any given period. The episodes were too short and the distances too long to permit satisfactory paleontologic correlation; the deposits vary from state to state, and from Gulf province to Atlantic province; beds come in and beds run out; limestones change to shale and shales to sandstone; with the changes in material there are changes in fossils, and the complex history recorded in the everchanging series has never been raveled; and not half the total thickness of the beds yields faunæ or floræ in sufficient wealth for close chronologic identification. Geologists have indeed formed general conceptions of the development of the province; but they have been hazy in detail, shadowy with respect to the succession of events, and vague with respect to quantitative measures of time or deposit. But the Appomattox formation, with the method of homogenic correlation which it largely inspired, enables the student to represent graphically and with fair accuracy the physiography of the southeastern part of the continent during a well defined episode.

ART. III.—*An experimental proof of Ohm's Law: preceded by a short account of the discovery and subsequent verification of the law;* by ALFRED M. MAYER.

I PURPOSE giving in this paper a simple and direct experimental proof of Ohm's law, $\left(C=\frac{E}{R}\right)$. Generally a mere formal statement of this law with illustrations are given in text books on Physics, and the student is left to infer that its truth is shown by the cumulative evidence given by the immense number of quantitative relations in electrical actions which the law associates, and by the experience that deductions made on the basis of this law agree in measure with the results of experiments. The latter fact is certainly one of the best proofs of the truth of the law; but, nevertheless, the relations between C, E and R are not directly and simultaneously shown to be exactly expressed by $C=\frac{E}{R}$. It is true that some works give experiments to show this relation but they are so difficult to perform by reason of the difficulty of maintaining constant C, E and R, that the results of the experiments only approximate to those required by the law.

Ohm was led to the conception of this law by *assuming* that the flow of electricity in a voltaic circuit is similar to the flow of heat by conduction in a rod of indefinite extent. Also, his assumptions that the actions of two electrified particles are directly as their distance and that the electricity is uniformly dense over each cross section of a conducting wire were directly opposed to the laws and facts well established by Coulomb for statical electricity. It is not surprising that scientific men were slow in adopting the views and theory of Ohm. In his memoir (Die Galvanische Kette mathematisch bearbitet von Dr. G. S. Ohm: Berlin, 1827), he states:* "Three laws, of which the first expresses the mode of distribution of the electricity within one and the same body, the second the mode of dispersion of the electricity in the surrounding atmosphere, and the third the mode of appearance of the electricity at the place of contact of two heterogeneous bodies, form the basis of the entire memoir, and at the same time contain everything that does not lay claim to being completely established. The two latter are purely experimental laws; but the first, from its nature, is, at least partly theoretical.

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* See translation, published in vol. ii. of Taylor's Scientific Memoirs, p. 402. London, 1841.

"With regard to this first law, I have started from the supposition that the communication of the electricity from one particle takes place directly only to the one next to it, so that no immediate transition from that particle to any other situate at a greater distance occurs. The magnitude of the transition between to adjacent particles, under otherwise exactly similar circumstances, I have assumed as being proportional to the difference of the electric forces existing in the two particles; just as in the theory of heat, the transition of caloric between two particles is regarded as proportional to the difference of their temperatures. It will thus be seen that I have deviated from the hitherto usual mode of considering molecular actions introduced by Laplace; and I trust the path I have struck into will recommend itself by its generality, simplicity, and clearness, as well as by the light it throws upon the character of former methods.

With respect to the dispersion of electricity in the atmosphere, I have retained the law deduced from experiments by Coulomb, according to which, the loss of electricity in a body surrounded by air, in a given time, is in proportion to the force of the electricity, and to a coefficient dependent on the nature of the atmosphere. A simple comparison of the circumstances under which Coulomb performed his experiments, with those at present known respecting the propagation of electricity, showed, however, that in galvanic phenomena the influence of the atmosphere may almost always be disregarded. In Coulomb's experiments, for instance, the electricity driven to the surface of the body was engaged in its entire expanse in the process of dispersion in the atmosphere; while in the galvanic circuit the electricity almost constantly passes through the interior of the bodies, and consequently only the smallest portion can enter into mutual action with the air; so that in this case, the dispersion can comparatively be but very inconsiderable. This consequence, deduced from the nature of the circumstances, is confirmed by experiment; in it lies the reason why the second law seldom comes into consideration.

The mode in which electricity makes its appearance at the place of contact of two different bodies, or the electrical tension of these bodies, I have thus expressed: when dissimilar bodies touch one another, they constantly maintain at the point of contact the same difference between their electroscopic forces [potentials].

With the help of these three fundamental positions, the conditions to which the propagation of electricity in bodies of any kind and form is subjected may be stated. The form and treatment of the differential equations thus obtained are so similar to those given for the propagation of heat by Fourier and Poisson, that even if there existed no other reasons, we might with perfect justice draw the conclusion that there exists an intimate connection between both natural phenomena; and this relation of identity increases, the further we pursue it. These researches belong to the most difficult in mathematics, and on that account can only gradually obtain general admission; it is therefore a fortunate chance, that in a not unimportant part of the propagation of electricity, in consequence of its peculiar nature, those difficulties almost entirely disappear."

From these premises, and guided by results of experiments made by him and by Ritter, Erman, Jäger, Davy and Becquerel he arrived at the following conditions as existing in a voltaic circuit.

1. In a homogeneous conductor, forming part of a voltaic circuit, the difference of the electric tensions at any two points of the conductor is proportional to their distance.

2. In different conductors forming part of a circuit, the difference of tensions at two points separated by an interval equal to the unit of length is in the inverse ratio of the section of the conductor and of its coefficient of conductivity. Hence, in different conductors, equal differences of tension correspond to lengths whose electric resistance is the same.

3. At the point of contact of two different conductors, there is a sudden variation of electric tension.

4. If A equals the sum of the electro-motive forces, L the resistances, λ the resistance reckoned from a point m of the circuit to a point p when the tension is zero, the tension at the point m is given by the formula

$$u = A\frac{\lambda}{L}.$$

Ohm eventually arrives at the formula $S = \frac{A}{L}$, which expresses what is generally known as his law. Which formula, he says, "is generally true, and already reveals the equality of the force of the current at all points of the circuit; in other words it may be thus expressed: The force of the current in a galvanic circuit is directly as the sum of all the tensions, and inversely as the entire reduced length of the circuit, bearing in mind that at present by reduced length is understood the sum of all the quotients obtained by dividing the actual lengths corresponding to the homogeneous parts by the product of the corresponding conductivities and sections."

The words "tension" (*Spannung*) and "electromotive force" used by Ohm are the equivalent of the word *potential*. He was the first to introduce this conception into the theory of

voltaic circuit and to the above words and to *current* and
istance he attached precise meanings and showed the rela-
ns existing between those quantities. The clear definitions
m gave of these terms marked a transition from vague ideas
"quantity" and "intensity" to the clear conceptions of
ential, electromotive force, current and resistance. The
rd *energy* he also used with clear and accurate meaning
is shown in the following statement: "that the decompos-
force of the circuit is in direct proportion to the energy
the current, and moreover, that it depends on a coefficient,
be derived from the nature of the constituent parts and
ir chemical equivalents." This was published in 1827, six
rs before Faraday's researches on electrolysis.

Neither Ohm nor his contemporaries were able to test the
th of the four statements given above as embodying Ohm's
ory. It was reserved for Kohlrausch in 1849 to show by
y ingenious and accurate experiments that Ohm's state-
nts were true in mode and in measure. Kirchhoff* and
incke† applied with success Ohm's theory to the flow of
ctricity in thin conducting plates, or bodies of two dimen-
ns, and the same was done by Smaasen ‡ not only in a plane
t in bodies of three demensions. The most remarkable con-
mation of Ohm's law was made in 1876 § by experiments,
gested by Maxwell and performed by Chrystal in the
vendish Laboratory, Cambridge, "in which the testing of this
r seems to have been carried to the limit of experimental
ources."

Though Ohm's law has thus received such ample verification
t it ranks with the best established laws of nature, yet, as
xwell says, "Ohm's law must, at least at present, be con-
ered a purely empirical one. No attempt to deduce it from
re dynamical principles has as yet been successful. . . .
e conduction of electricity through a resisting medium is a
ocess in which part of the energy of an electric current,
wing in a definite direction, is spent in imparting to the
lecules of the medium that irregular agitation which we
l heat. To calculate from any hypothesis as to the molec-
r constitution of the medium at what rate the energy of a
en current would be spent in this way, would require a far
re perfect knowledge of the dynamical theory of bodies
n we at present possess. It is only by experiments that we
determine the laws of processes of which we do not under-
nd the dynamical theory."

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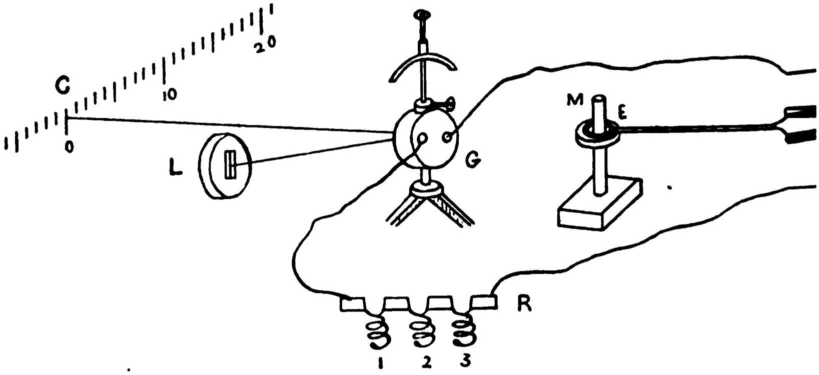
* Pogg. Ann., t. lxiv, 1845. and t. lxvii, 1846.

† Pogg. Ann., t. xcvii, 1856.

‡ Pogg. Ann., t. lxiv, and t. lxxii.

§ Brit. Assoc. Rept., 1876, p. 36.

Surely if an experiment, that is easily made, shows the truth of a law of such theoretical and practical importance as that of Ohm, even if it is one restricted in its range of C, E and R, but shows within its limitations the relations $C=\frac{E}{R}$, then it should be made by all teachers of Physics so that clear physical conceptions of those relations may be given to students. As those who have seen these experiments have deemed them worthy of being more generally known, I now publish an account of them.



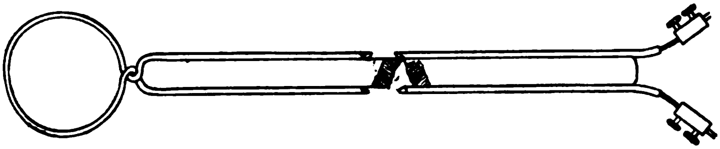
In the diagram the parts of the apparatus are shown, but not at their relative distances apart or in the proper proportions as to size. G is a low-resistance Thomson-galvanometer. At L is the condensing lens of a lime-light lantern, which is covered with a cap having a rectangular opening in it. Across the middle of this slit is a vertical wire. The scale of the galvanometer is at C, distance 165^{cms} from the mirror of the galvanometer. The width of the divisions on this scale are $2{\cdot}5^{cms}$, and the lines are drawn $2{\cdot}5^{mms}$ in breadth, or $\frac{1}{10}$ the distance apart of the centers of the lines forming a unit of the scale. The scale is at such distance from the galvanometer-mirror that the image of the vertical slit just fits in the space of a scale unit, while the breadth of the image of the vertical wire is exactly equal to the breadth of a scale line. This arrangement gives the means of observing a deflection of the beam of light to $\frac{1}{10}$ and $\frac{1}{20}$ of a unit with quickness and accuracy.

The image of the slit is so bright and that of the wire so distinct that this method of observing deflections of the galvanometer may be used in broad day light and the deflections may be read throughout the room.

An incandescent electric lamp with a part of its surface ehind the plane of its filament) silvered may replace the ne-light. Thanks to this arrangement, I have been able ring many years to make before my class electrical measure-ents, and to measure the radiation, reflection, refraction, athermancy and polarization of radiant heat.

At M is a magnet $25^{\text{cms.}}$ long and $1\frac{1}{2}^{\text{cms.}}$ in diameter. On this agnet slides a wooden disc. At R is box containing 1, 2 and Ohms of resistance, made of coils of copper wire.

An insulated copper wire wound at its middle in a circle of ne coil, or in a spiral of any number of coils is placed over the agnet and rests on the top of the wooden disc. The figure



shows, (one-half size) how this circle of one coil is made. It is bent around a wooden cylinder $3\frac{1}{2}^{\text{cms}}$ in diameter, and then the free ends of wire are bent one half turn on each other. The free lengths of the wire are then lashed to a light square rod of wood as shown in figure. The wire and rod are then coated with shellac to cement them firmly together. Rings of spirals of 2, 3, 4, 5 and 6 coils are also made in the same manner, but the coils are in a spiral, i. e. in one plane, and are then cemented together with shellac between rings of thin card-board.

The length of wire forming each of these rings of spiral coils with the portion on its handle is one meter long.

The resistance of this length of wire added to the resistance of the lengths between it and G and R, together with the resistance of the galvanometer is (for convenience) made one ohm.

It may be well here to speak of the adjustment of the galvanometer before describing the experiments, for I have noticed in some laboratories and lecture rooms galvanometers which are used not as they should be. I have noticed that the damping-magnet formed a considerable angle with the plane of the coil. This was either because the median plane of the coil was not in the magnetic meridian or because there was considerable torsion in the suspending thread.

In these galvanometers, or, at least, in mine, the median plane of the coil is placed parallel to the faces of the drum of the instrument. The plane of one of these faces is brought in the magnetic meridian of the room, which has been carefully drawn on the table under the vertical center line of the galvanometer coil, by means of a long magnetic needle mounted like those used on plane-tables. A line at right angles to this meridian is now drawn so that its point of intersection with the meridian line shall be exactly under the suspending thread of the mirror. In the vertical plane of the line, drawn at right angles to the meridian, is placed the vertical wire in the slit of the lantern, L, and also the zero line of the scale C. The scale is parallel to the magnetic meridian. The galvanometer is now placed in the position given above and the "directing magnet" removed to a distance. The image of the vertical wire at L will now be found on the zero of the scale if there is no torsion in the suspending thread. If it does not come to zero then the head of the rod to which the thread is attached is turned till image of wire coincides with zero of scale, and then the instrument is in adjustment, and it will give deflections as the tangents of the strength of current, or, in other words, the current strength will be directly as the readings on the scale. The magnet M is now placed so that it causes no movement of beam from the zero of the scale. The directing magnet, above the coil, is now so adjusted that the time of an oscillation of the magnets of the galvanometers is above 5 seconds.

The coil, E, over the magnet is put in the circuit of G and R. The wires between E and G and R are twisted and tied together so that no induced current from the earth's magnetism may be caused by the motions of this part of the circuit. The image of wire is on zero of scale. Now on rapidly lifting the coil from around the magnet a deflection is produced by the magneto-electric current thus generated. It is sufficient to know that the cause of this current is the quick lifting of the ring with one coil. If we replace this by a ring of two coils we get twice the deflection, and rings of 3, 4, 5, and 6 coils gives 3, 4, 5, and 6 times the deflection given by the ring with one coil. Adopting the conception of the lines of magnetic force, we say that the ring with one coil cuts a certain number of these lines, this cutting of the lines causes the current, and is *the electromotive force.* The ring with two coils makes two cuts of these same lines, or, cuts double the number of lines, the rings of 3, 4, 5 and 6 coils cut 3, 4, 5 and 6 times the number of lines and hence give 3, 4, 5 and 6 times the electromotive force.

In these experiments the resistance of the circuit has remained constant. Now take the ring with 5 or 6 coils and let us have one ohm as resistance of circuit. On lifting ring from magnet we get a certain deflection, which we may make exactly equal to a whole number of the units of the scale by liding up or down the disc on the magnet. We now take out lug of resistance box and make resistance of circuit two ohms. he deflection of the galvanometer magnet now becomes one alf of that of previous experiment, and successively making he circuit with resistances of 3, 4, 5, 6, and 7 ohms we get, , $\frac{1}{4}$, $\frac{1}{5}$, $\frac{1}{6}$, and $\frac{1}{7}$ of the deflection we got with one ohm in ircuit.

When these experiments are made with the galvanometer in erfect adjustment, and with the precautions indicated below, he deflections arrive one after the other exactly as the law equires. Thus showing with sufficient precision for a lecture xperiment that the current is directly as the electromotive orce and inversely as the resistance. Indeed generally the losest scrutiny does not detect in the scale reading any de-arture from the law.

Certain precautions are, however, necessary in these experi-nents. The resistance outside the galvanometer must be of opper wire, for such is the wire of the galvanometer. Also, he whole of the apparatus must be put together the day before e make the experiments, and the room maintained at as con-tant a temperature as possible, so that the temperature of all arts of the apparatus is the same. The deflections should not xceed 15 divisions of the scale. Thus, if we start with 15 divis-ons of deflection for a resistance of one ohm we will get 7·5; ; 3·75; 3; 2·5; and 2·143 deflections for resistances of circuit f 2, 3, 4, 5, 6 and 7 ohms; and if with a constant resistance e obtain a deflection of 2 divisions of scale with a ring of one oil, we will get deflections of 4, 6, 8, 10, and 12, with rings aving 2, 3, 4, 5 and 6 coils.

It is necessary that the coils should be removed from the nagnet *very quickly*, otherwise the deflections will not be as he law requires. In other words, the currents produced should e as instantaneous as can be obtained. Instead of rapidly re-moving the coils by the hand, I have sometimes lashed the coil and their handles to a spring board with a hole in it which went over the magnet. By a trigger this spring-board is re-leased. We thus get the same velocity in lifting the coil in each experiment. We have found, however, that the hand of a good experimenter gives precise results. Sometimes I have sent the coil from the magnet by the blow of a stick delivered on the under side of the handle of the coil at its center of percussion. There is no doubt some departure from the law in these experiments, for it is not possible in such ex-periments to obtain what is understood by instantaneous cur-rents; and the damping of the magnet by the mirror acting on the air must come into play. Yet I have never seen any but insignificant and barely discernable departures from deflections required by the law. This follows from the small angles of deflections and low velocity of the motion of the galvanometer magnet in the experiments. It is also to be noticed that with a good magnet of the size stated, and with the galvanometer making one vibration in about 5 seconds, the coil with 5 turns passes over only 2 cms. or less, of end of magnet in order that it shall give a deflection of 15 divisions of scale. It is evident that in these conditions a very short time is occupied in cutting the lines of force. If the maximum deflection used is 15 divisions of the scale, the actual angular deflection of the magnets and mirror amounts to only 6° 29′. Yet 15 divisions are quite a length on the scale, being equal to 37·5 cms. But these experiments may be as readily made with a ballistic galvanometer. Then the magnets and coils have to be of larger dimensions.

Experiments similar to those given have served to graduate galvanometers. We have here the means of sending definite amounts of currents through an ordinary galvanometer and we may thus graduate its angular readings into their relative values in current. The damping of the galvanometer has, however, to be applied to the readings, and then the results may best be put in the form of a curve.

Stevens Institute of Technology, Hoboken, N. J.

ART. IV.—*Microscope Magnification*; by W. LECONTE STEVENS.

WHEN a lens is interposed as magnifier between the eye and an object, it produces a virtual image of this, the accommodation of the eye being so adjusted as to relax the ciliary muscle and thus secure the most comfortable vision. For normal eyes this occurs when the entering rays are parallel, rather than when the accommodation is for the conventional near-point of distinct vision. The position of the virtual image is hence indeterminate; but by common consent it has been generally agreed to consider its distance on the axial line to be 10 inches, or 254 millimeters, from the optical center of the lens.

It can be easily shown that, if the lens and object be fixed, the increase of visual angle produced is a maximum when the eye is closest to the lens. It is never possible to measure accurately the distance from the optical center of the lens to that of the refracting combination composing the observer's eye. In theoretical calculations an allowance should be made for it; practically it is regarded as zero.

By some authors a distinction is made between the terms "magnification" and "amplification," and still further between "relative," "comparative," and "absolute" amplifying power.* Whatever may be the value of these distinctions in theory the writer can find no good reason for discarding the familiar term, magnification, to denote the ratio of the diameters of the retinal images produced with and without the magnifying lens, or system of lenses, respectively. The conditions under which the magnifying system is employed are to some extent arbitrary.

To compute the magnification given by a microscope it is necessary to multiply together the separate magnifications due to the eye-piece and objective employed. Unfortunately the nomenclature of eye-pieces and objectives is still far from satisfactory; and it would perhaps be safe to say that the majority of persons who employ them are unable, under existing limitations, to do more than accept certain labels and use these in calculation. But the labels are misleading. To call an eye-piece "shallow" or "deep," or to name it an A, B, or C eye-piece, affords no definite idea of its power. Such arbitrary and useless designations deserve to be abolished. An eye-piece should be labeled with its equivalent focal length like an objective; and in each case the label should be accurate to within one millimeter. This method of labeling eye-pieces was recommended several years ago by the American Society of Microscopists, but thus far there has been very little compliance on the part of manufacturers. Tables of magnification are given by certain firms for combinations of objectives with eye-pieces as sold by them; but the purchaser has to take these figures on trust. They are professedly applicable only when "standard tube-length" is employed. Such a standard exists only in name and not in fact. In 1887 Professor S. H. Gage, of Cornell University, applied to all of the prominent makers of microscopes in the world for information as to the tube-length for which their objectives were corrected, enclosing to each a diagram upon which should be marked those points on the microscope body which were taken as the limits of tube-length. From eighteen of these firms, including the majority of those addressed, satisfactory answers were obtained. Among the lengths given, the following in millimeters may be taken as examples: 125, 146, 150, 160, 165, 180, 190, 200,. 203, 216, 220, 228, 250, 254. The last of these numbers occurs most frequently, corresponding to 10 inches. Examination of the diagrams revealed equal diversity in regard to the points taken as the limits of tube length. In one case it was from the upper surface of the eye lens to the lower extremity of the objective; in another, from the upper surface of the field lens to that of the topmost lens of the objective.

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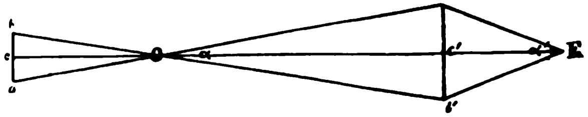
* L. Didelot, "Du Pouvoir amplifiant du microscope," Paris, 1887.

The present writer had occasion, some time since, to purchase a binocular microscope, with several objectives and eye-pieces, for which a table of magnification was furnished. Examination of this table showed that the magnification was calculated by dividing 100 by the product of what were called the focal lengths of objective and eye-piece, expressed in inches. On inquiry of the dealer this rule was found to be the one he had employed, and it was said to be in common use. Its results were admitted to be only approximate, but it was supposed to be near enough to the truth for most practical purposes.

It has seemed desirable, therefore, to test this rule, and in so doing to search out a few points that may possibly be of interest to those who use the microscope as a physical instrument. Its deduction is very simple. Let the object, *ab*, be

1.



focalized by the objective, O, at *a′b′*. O*c* is taken as the focal length of the objective, and O*c′* as the tube-length, 10 inches. If *m* be the magnifying power of the objective alone, we have,

$$m = \frac{a'b'}{ab} = \frac{10}{f}.$$

The visual angle, *α*, subtended at O by *a′b′* is the same as that subtended by *ab*, if an eye placed at O were capable of sufficient accommodation to secure distinct vision at so short a distance. The image, *a′b′*, is viewed with an eye-piece, which increases the visual angle from *α* to *α′*, producing a virtual image which is assumed to be 10 inches away. If *m′* be the magnifying power of the eye-piece whose focal length is *f′*, we have, approximately,

$$m' = \frac{\tan\frac{1}{2}\alpha'}{\tan\frac{1}{2}\alpha} = \frac{10}{f'}.$$

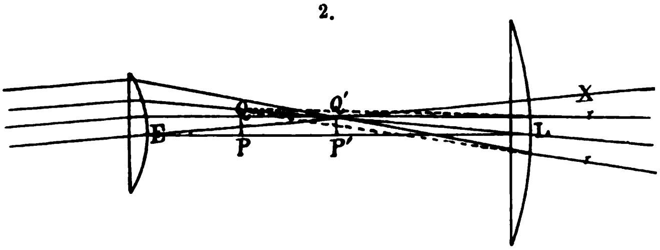
If M be the total magnification, the result therefore is

$$M = mm' = \frac{100}{ff'} . \quad . \quad . \quad . \quad (1).$$

In applying this formula, if previous measurements have not been made upon the lenses composing the eye-piece, a difficulty arises in regard to the value to be assigned f', since eye-pieces ordinarily have no labels more intelligible than A, B, or C, which numerically mean nothing. If a positive eye-piece be employed, the focal length of its two lenses being equal, the equivalent focal length of the combination is obtained by the usual formula, if that of either of the two lenses, and the interval between their optical centers, be measured. In case the eye-piece be negative, a majority of those in use belonging to this class, the focal length of its eye lens is easily found by allowing for its thickness and measuring down to the diaphragm where the real image is formed. But the size of this image has been decreased, and its position has been changed by the interposition of the field lens. At the risk, therefore, of giving what seems very elementary, it may be well to consider briefly the theory of the negative eye-piece.

We may assume the proportions usually said to be adopted in the construction of the negative eye-piece, that the focal length of the field lens is three times that of the eye lens, and the interval between these equal to the difference of their focal lengths. The rays, *r r*, fig. 2, converging from the objective toward the point, Q, have their convergence increased by the field lens, so as to cross at Q′. They are made parallel by the eye-lens, and emerge so as to produce a virtual image which to the receiving eye appears in the direction E X. Hence Q′ is in the principal focal plane of the eye lens, and Q in one conjugate focal plane of the objective.

2.



Let $EP' = f' =$ focal length of eye lens.
" $3f' = f'' =$ " field lens.
" $LP = p =$ distance of virtual point of radiance.
" $LP' = p' =$ " actual " convergence.

Then, by the fundamental law of lenses,

$$\frac{1}{p'} - \frac{1}{p} = \frac{1}{f''}.$$

Since $EL = 2f'$, and $EP' = f'$, we have $p' = f'$. Hence,

$$\frac{1}{f'} - \frac{1}{p} = \frac{1}{3f'} \quad \therefore p = \frac{3}{2}f'$$

$$\therefore \mathrm{PQ} = \frac{3}{2}\mathrm{P'Q'}.$$

The focal plane of the objective is hence midway between the eye lens and its focal plane; and the diameter of the image actually viewed with this lens is two-thirds of that which would have been formed if the field lens had been absent. If we assume $\frac{10}{f}$ as the magnifying power of the objective when no field lens is used, the interposition of this lens reduces it to $\frac{2}{3}\cdot\frac{10}{f}$. This reduction of magnification is more than offset by the well known advantages which the field lens confers. Introducing the proper correction in formula (1), this becomes

$$\mathrm{M} = \frac{2}{3}\frac{100}{ff'}. \quad . \quad . \quad . \quad . \quad (2).$$

Formula (2) implies a knowledge of the focal length of the objective and of only the eye lens. To find the equivalent focal length of the eye-piece combination, let F stand for this length, f' and f'' for those of eye lens and field lens respectively, and d for the interval between these lenses. Then the usual formula for the combination is

$$\frac{1}{\mathrm{F}} = \frac{1}{f'} + \frac{1}{f''} - \frac{d}{f'f''}. \quad . \quad . \quad . \quad . \quad (3).$$

In this case $f''=3f''$ and $d=2f$. Substituting, we have

$$f' = \frac{2}{3}\mathrm{F}. \quad . \quad . \quad . \quad . \quad (4).$$

Introducing this value of f' in formula (2), the result is

$$\mathrm{M} = \frac{100}{\mathrm{F}f}. \quad . \quad . \quad . \quad . \quad (5).$$

The value of f is labeled on the mounting of the objective, and that of F is easily obtained by applying formula (4), f' being found without calculation, as suggested above, if great accuracy is not required.

In formula (5), 100 is the product of two factors. One of them is the assumed distance at which distinct vision with the unaided eye is most easily attained. It may be taken as 250 millimeters, which is very nearly 10 inches. The other is the distance from the focal plane of the objective to what we may provisionally call its optical center. If we make this last distance our definition of tube length, use for it the symbol T, and let D stand for the distance of distinct vision, our formula becomes,

$$M = \frac{DT}{Ff} \quad . \quad . \quad . \quad . \quad (6)$$

remains now to be seen what modifications need to be im-
l upon formula (6), since formula (1), from which it is
oped, is confessedly only approximate. Its second mem-
hould be equal to the product of the magnifying powers,
ıd m', of objective and eyepiece respectively, as deter-
d by experiment.

suming that the eye-piece has been constructed in accord-
with the conditions implied in the formula, F is to be
mined from f'', which in turn can be measured with but
error by use of the camera lucida. Let an eyepiece mi-
eter be placed at the diaphragm and properly illuminated,
nicroscope body being so tilted that the optical center of
ye lens shall be 250^{mm} above the white paper on the table.
ı the camera lucida the divisions of the micrometer are
cted on the paper, and the magnification, m', is directly
mined. To find f'', since the image is virtual, the value
' is substituted in the formula,

$$m' = \frac{D}{f''} + 1 \quad . \quad . \quad . \quad . \quad (7)$$

method may be checked by detaching the eye lens and
ng it independently by Cross's formula, to be presently
n.

ıe value of f, the focal length of the objective, cannot be
rmined by ordinary methods because the microscope ob-
ve usually consists of two or more systems of lenses, each
up of a crown and a flint; and the error involved in
uring the thickness of each of these separately and also
distance apart is so considerable as to make the final
t very uncertain. The best formula to apply is that
ced some years ago by Prof. C. R. Cross.* This formula
such importance that its deduction and application are
given in this connection.

t the field lens of the eye-piece be removed, and two
ometer scales be employed, one of which, divided into
s of a millimeter, is placed on the stage as an object, while
ther, divided into millimeters, is placed at the diaphragm
he focal plane of the eye lens. The image of the stage
ometer is focused upon the eye-piece micrometer, and the
parison of these images gives the magnifying power, m, of
objective at the distance selected. Assuming provisionally
ptical center for the objective under the given conditions,

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* Journal of the Franklin Institute, vol. lix, p. 401.

Let $p =$ distance of stage micrometer from this optical center.
Let $p' =$ " eye-piece " " "

Then, $$m = \frac{p'}{p}, \text{ or } p = \frac{p'}{m} \quad . \quad . \quad . \quad (8)$$

It is impossible to measure either p or p' directly, but we can measure the distance between the two micrometer scales, which is equal to their sum. Calling this l, we have,

$$l = p + p', \text{ or } p = l - p' \quad . \quad . \quad . \quad (9)$$

Eliminating p between equations (8) and (9),

$$p' = \frac{ml}{m+1} \quad . \quad . \quad . \quad . \quad (10)$$

From the equation of lenses,

$$\frac{1}{p} + \frac{1}{p'} = \frac{1}{f}, \text{ we have } f(p + p') = pp' . \quad . \quad (11)$$

Substituting in equation (11) from equations (9) and (10), and reducing, the result is

$$f = \frac{ml}{(m+1)^2} \quad . \quad . \quad . \quad . \quad (12)$$

Since this formula is independent of p and p', it may be applied without any knowledge of the optical center of either a single lens or a system of lenses.

The eye-pieces of the microscope to which reference has been already made are devoid of labels, although the instrument is a fine one, and the maker was one of the best known in America, a careful and intelligent German, now dead. They have been subjected to measurement, with the result given in Table I. The two eye-pieces labeled in the table A_1 and A_2 were evidently intended to be, in ordinary nomenclature, 2-inch eye-pieces; those labeled B_1 and B_2, 1½-inch eye-pieces, and the one labeled C, a ¾-inch eye-piece. All measurements of length were made in millimeters.

TABLE I.

1.	2. f'	3. f''	4. d	5. F	6. $\frac{3}{2}f'$	7. F′	8. e %	9. m'
A_1	35·5	58·8	54·0	51·8	53·2	2·07	−3·4	5·82
A_2	34·9	58·1	54·0	52·0	52·3	2·08	−3·9	5·82
B_1	21·3	40·0	38·0	36·6	31·9	1·46	+2·7	7·83
B_2	21·1	40·9	38·0	36·0	31·6	1·44	+4·2	7·94
C	13·6	28·7	23·0	20·2	20·4	·81	−7·4	13·38

On comparison of columns 2, 3, and 4, it is seen that in no case is $f'' = 3f'$, or $d = 2f'$, as generally assumed in relation to the negative eye-piece. To multiply the focal length of the by $\frac{2}{3}$ does not therefore give the equivalent focal f the combination. The approximation, as shown in and 6 is moderately good in eye-pieces A_2 and C, but eans so in B_1 and B_2. In column 5 the value of F was d by formula (3), and the results translated into inches nn 7. Column 8 shows the percentage of error in the equivalent focal lengths of the eye-pieces, and column their actual magnifying power. Each of the data of 2 and 3 is the mean of five independent measure- but the results in column 9 are affected with a error greater than what should be expected if F could n obtained directly from f' alone.

aker of an eye-piece ought certainly to know how to work after it is finished. He has the right to use any in construction that experience has shown to be valu- ut in every case the value of F ought to be determined ly by him, and labeled on the mounting of the eye- t in whole inches or aliquot parts of an inch, but in parts of an inch, or, still better, in millimeters. The world is familiar enough with the metric system to the abolition of other systems, at least in the construc- ll new instruments.

TABLE II.

1.	2.	3.	4.	5.	6.
	l	*m*	*f. mm.*	*f. inches.*	*e%*
W. 3	315	3·93	51·0	2·01	+50
B. 2	303	6·25	36·1	1·42	+41
R. $1\frac{1}{2}$	300	7·10	32·4	1·28	+17
B 1	293	9·33	25·6	1·01	−1
B. $\frac{3}{4}$	284	13·50	18·2	·716	+5
W. $\frac{3}{4}$	296	14·00	18·4	·724	+4
B. $\frac{1}{2}$	288	18·80	13·5	·531	−6
C. $\frac{1}{4}$	290	55·00	5·1	·202	+24
B. $\frac{1}{6}$	283	58·00	4·7	·185	+7
W. $\frac{1}{12}$	277	115·0	2·36	·093	−10
B. $\frac{1}{16}$	287	170·0	1·68	·066	−5

plying formula (12) to the determination of the focal of objectives it is found that the labeling of these is in ses very erroneous. In the paper to which reference dy been made Professor Cross gave his measurement than thirty objectives from various sources. In one objective, marked $\frac{4}{10}$ inch, should have been marked $\frac{1}{4}$ he measurements made by the present writer and re- n Table II above, may give some idea of current errors in this respect. In column 1 the capital letter arbitrarily stands for the name of a maker, and the adjacent figures for the focal length of the objective as labeled, in inches or fractions of an inch, on the mounting. Column 2 gives the distance in millimeters between the stage and eye-piece micrometers, determined by the length of the microscope body; and column 3, the corresponding magnification attained. Column 4 gives the computed focal length in millimeters, which in column 5 is reduced to inches for the sake of comparison; and column 6 gives roughly the percentage of error of the label.

On examination of Table II it is seen that the errors of the labels are more frequently positive than negative, or that objectives are more frequently labeled too low in power than too high; and that the errors are unpardonably great in the objectives of lowest power. It seems scarcely conceivable that an error of 40 or 50 per cent could be made and deliberately stamped on the mounting of an objective whose real focal length is so easily found by experiment. It should be observed that any error due to thickness of cover glass is negligible when the focal length exceeds 20^{mm}. The stage micrometer used in these experiments was uncovered; and since the higher powers are usually adjusted to give their best definition when a definite thickness of cover glass is employed, this fact may partly account for the negative errors found in the two highest powers examined, although the adjustment of collar in these measurements was for use without a cover glass.

Having obtained the magnifying powers of objective and eye-piece, their product is the total magnifying power of the combination. If the equivalent focal length of the eye-piece is definitely known, its magnifying power, m', is obtained by applying formula (7). If the tube length, T, and focal length, f, of the objective are known, its magnifying power, m, may be accurately obtained. For, referring to fig. 1,

$$m = \frac{a'b'}{ab} = \frac{T}{Oc}. \quad \text{But } \frac{1}{Oc} + \frac{1}{T} = \frac{1}{f}. \quad \therefore Oc = \frac{Tf}{T-f}. \quad \text{Hence,}$$

$$m = \frac{T}{f} - 1. \quad . \quad . \quad . \quad . \quad . \quad (13)$$

In formula (13), if f be very small in comparison with T, the term -1 may for all practical purposes be neglected. But to do this involves serious error when objectives of low power are employed.

Table III shows the result of using eye-piece B_1 of Table I successively in combination with five of the objectives of Table II, the values of m' and m being taken from these two tables. Column 2 gives the values thus calculated, while column 3 gives the corresponding results independently obtained with the camera lucida. The next two columns result from pplying the formula $M = \frac{100}{Ff}$ and reducing to millimeters; n column 4 the values of F and f have been taken from Tables I and II, and in column 5 they are the nominal focal engths, as indicated by the manufacturers.

TABLE III.

1.	2.	3.	4.	5.
Combination.	$M = mm'$.	Camera.	$M = \frac{100}{Ff}$	$M = \frac{100}{Ff}$
$B_1 \times W . 3$	30·8	30·4	34·14	22·22
$B_1 \times R . 1\frac{1}{2}$	55.3	55·0	53·68	44·44
$B_1 \times W . \frac{3}{4}$	109·6	107·0	94·60	88·88
$B_1 \times C . \frac{1}{4}$	430.6	433·0	339·0	266·7
$B_1 \times W . \frac{1}{12}$	900.0	900·0	736·0	800·0

Table III shows, as might be expected, that the uncertainty of results increases with the power of the objective. Theoretically, columns 2 and 3 ought to be identical. Practically they are nearly so for low powers, but the difficulty of taking exact measurement with high powers is very great. The inaccuracies revealed in column 4 are due partly to the fact that the formula is only approximate, but also because the tube length is not 250 millimeters, and cannot possibly have this value with the instrument employed. In column 5 erroneous values of F and f, taken from the labeling, so greatly increase the errors of column 4 as to make the measurements worthless. Yet these are the results of calculation as commonly applied to the data furnished by the manufacturers

In using the camera lucida the difficulty increases when the higher powers are employed, just as much as in applying Cross's formula. Under any circumstances, therefore, a wide margin of uncertainty exists in estimating the magnification attained with objectives of high power. Although the figures given are in each case the mean of many measurements, the remarkable agreement in the two results attained with the $\frac{1}{12}$th is doubtless to some extent accidental. With medium and lower powers it is shown by comparison of columns 2 and 3 that results about equal in value to those with the camera lucida are had by taking the product of the separate magnifications due to objective and eye-piece. And formulas (6), (7) and (13) show that this product may be expressed as

$$M = \frac{(D+F)(T-f)}{Ff} \quad . \quad . \quad . \quad (14).$$

This formula is fully worthy of reliance if accurate values of the equivalent focal length of eye-piece and objective, respectively, are stamped on their mountings, and if the tube-length also is stamped on the microscope body.

But the difficulty of securing definiteness and uniformity in tube length is probably greater than that of securing proper labels on the mountings of the lenses. It is necessary to fix upon two points of the microscope body as the upper and lower limits of the tube-length, and additionally for some agreement to be reached among makers as to the tube-length selected. What this shall be is a matter partly of precedent, partly of convenience. The nominal standard is 10 inches in England and America, but there is no pretense of adhering to it. In Germany and the continent of Europe generally, about 180 millimeters is perhaps most common. The latter is for some reasons more convenient, and seems to be gaining in popularity.

From what has preceded it is obvious that the upper limit of the tube-length should be the focal plane in which an image would be formed by the objective if no field lens were interposed. If the eye-piece is made to fulfil the generally assumed condition that the focal length of the field lens shall be three times that of the eye lens, and the interval between them shall be twice the focal length of the eye lens, the focal plane in question would be just midway between the diaphragm of a negative eye-piece and the optical center of the eye lens, which is at the middle of its convex surface. The eye-piece should be so constructed that when it is slipped into position this focal plane shall be exactly at the top of the microscope body, which then serves always as the upper limit of tube-length. The desirability of making all eye-pieces thus "parfocal" has been already suggested by several writers. There is no practical mechanical difficulty in attaining this end. In case the negative eye-piece should not fulfil the generally assumed conditions, the distance of the parfocal plane above the diaphragm is easily found. Referring to Fig. 2, and using the same notation, this distance is P′P, or $p-p'$, which, from the formula $\frac{1}{p'}-\frac{1}{p}=\frac{1}{f''}$, is equal to $\frac{p'^2}{f''-p'}$. The required distance of parfocal plane above diaphragm is thus given in terms of the focal length (f'') of the field lens and the distance (p') of the diaphragm from the optical center of this lens.

It should in justice be mentioned in this connection that at least one celebrated European firm, that of Carl Zeiss, in Jena, has for several years past been making all of its eye-pieces parfocal. This is only one of the many good things for which the scientific world is indebted to Professor E. Abbe, a phys-t whose work in microscopical optics has been so thorough t scarcely anything in this domain can be undertaken by cotemporaries which he has not already mastered. It is to regretted that the makers of microscopes generally should so slow in following a good example.

The determination of the lower limit of the tube length is htly complicated by the fact that a microscope objective sisting of two or more systems of lenses, has no fixed point ough which all axial rays will cross when the position of point of radiance is varied. Its equivalent focal length ies within narrow limits according to the distance of the al plane in which the image is formed. According to the iter's experiments it increases slightly as this distance is reased. The objective labeled R. 1½ in Table II was exam-d on an optical bench, the distance, *l*, between the points of iance and convergence being varied from 160 mm. to 700 n., and *f* calculated for 20 successive values of *l*. The mean the first 10 values was 32·14 mm.; that of the second 10 was 38 mm., the extremes being 32·0 mm. and 32·5 mm. This ective consisted of two systems of lenses. A three-system ective of nominal ¼-inch focal length, and an objective of e system, were likewise examined, with the result shown in ble IV:

TABLE IV.

Label of Objective	W.3	R.1½	C'¼
Number of systems	1	2	3
Limits of *l*, in mm.	202–800	160–700	130–520
Number of measurements	12	20	14
f from first half, in mm.	50·05	32·14	5·60
f from second half, in mm.	50·00	32·38	5·70

From this table it is seen that the variation does not exceed enth of a millimeter in the highest of these powers, a quan- that is negligible in comparison with the whole tube-gth. Assume then that the distance from the top of the roscope body to the extremity where the objective is ewed in is a little shorter than the desired tube-length; for mple, 160 mm., if 180 mm. is selected for tube-length. en in the formula, $\frac{1}{p}+\frac{1}{p'}=\frac{1}{f}$, we have $p'=180$, and f is own, hence p is calculated. The "working distance" be-een a slide and the exposed lens can be measured; and on btracting it from p we have the distance, within the objec-e, of the point which for the given tube-length behaves like optical center. This point, by the given formula, is known be 20 mm. from the extremity of the microscope body, and ence the desired allowance can always be made in the mount-g to put this point in its proper place. The optical tube-length for which an objective is corrected should always be stamped on its mounting along with the record of exact focal length and numerical aperture.

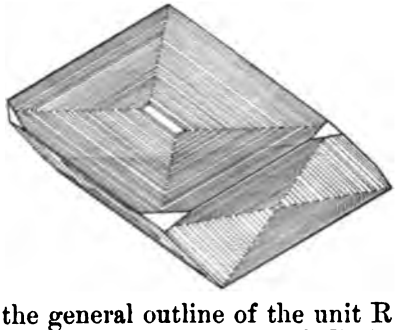
If there be accurate labeling of optical tube-length, and of the equivalent focal length of eye piece and objective, the camera lucida ceases to be a necessity to the user of the microscope. Under present conditions, however, and until better methods are adopted by the majority of manufacturers, it is the only ready means of approximating toward the correct measurement of microscope magnification.

Brooklyn, N. Y., April 2, 1890.

ART. V.—*Notes on the Minerals occurring near Port Henry, N. Y.*; by J. F. KEMP.

DURING the summer of 1889 the following notes on minerals occurring near Port Henry, N. Y., were made, largely with the aid of Mr. W. H. Benedict, then in charge of the local high school. At the abandoned Pease quarry, a short distance northwest of the town, a face of white crystalline limestone has been laid bare, and in this occur streaks consisting chiefly of hornblende, plagioclase, muscovite and quartz, but containing as well a great abundance of yellowish brown titanite crystals. These latter average perhaps an inch, along $\dot{c}$, by one-half inch along b, and are bounded by large 2P and 0P and less prominent $\infty P\bar{\infty}$ and ∞P—making the common semeline type. Individuals appear to have been wrenched or broken, possibly by mountain-making action. Fine brown tourmalines occur with them in the same associations and are also wrenched and bent. In one instance a crystal one and one-half inches long, is bent around through at least 70°, yet without notable fracturing. West of the Pease quarry is a quarry where flux was being obtained for the local furnaces. The rock is a beautifully clear crystalline limestone with excellent, small, hexagonal tables of graphite disseminated through it. Occasionally lemon yellow calcite is found, but of especial interest are the fine crystals of clear calcite of the general outline of the unit R with a low striated four-faced pyramid imposed on each R face, and often truncated by R

1.



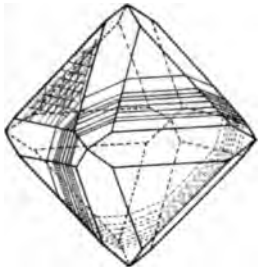
elf. (See Naumann-Zirkel, Mineralogie, fig. 13, under cal- te). This is caused by an oscillation between R and two or ore scalenohedra, whose long polar edges, and combination lges are on the diagonals of the R face. Although in general e faces are not well adapted to measurement, enough good sults were obtained to indicate 2/7 R 9/5 as one of the scaleno- dra present above R, and various results for the angle Y led the suspicion of two others. Below the R face there are also ro or more scalenohedra indicated, but the only one of which easurements were obtained proved to be near 13/11 R 9/7.

	Y measured.	Y calculated.	X measured.	X calculated.
3/7 R 9/5	166·21	166·10	129·18	130·10
	166·01		129·25	
	165·50		129·27	
			130·12	
13/11 R 9/7	170 43	170·30	Z measured.	Z calculated.
	170·25		96·19½	96·30
	170·26		96·44	

R4 is also present upon all the crystals. The forms deter- ined by Hessenberg on the combination above cited from aumann were R2 and 2/5 R2. The crystals are excellent lustrations of oscillatory forms. Still west of this quarry is e Treadway quarry in ophicalcite. Through this rock run t times narrow streaks with pyrrhotite, quite large leaves of hlogopite, brown tourmaline and well-crystallized light-brown emolite ($\infty P, \infty P\bar{\infty}, \infty P\breve{\infty}$ and $-P$). A visit to the now bandoned feldspar quarry six miles northwest of Port Henry rom which came the peculiar tourmaline crystals described y Professor E. H. Williams (this Jour. III, xi, 273), revealed e fact that it is probably a great feldspathic mass, either in neiss or granite (probably akin to the pegmatitic segregations ommon in many granitic masses), and cut by three narrow ap dikes, now much altered but doubtless originally diabase. he tourmalines favor certain lines, and along these they occur in olated single crystals and as matted aggregates. Great masses f biotite, as large as a barrel occur also in streaks, yielding ood cleavage masses under the sledge, and fine specimens of se quartz are less abundant. The quarry is called Roe's spar- ed.

At Mineville, one of the newer openings (the so-called overs' Pit) on Barton Hill is affording crystals and cleavage asses of magnetite of unusual size and excellence. The crys- ls are combinations of O and ∞O, and vary up to an inch d more in diameter. They are buried in granular magnetite great purity. The faces are marked by striæ parallel with e O edges and at times running quite around the crystal. It can hardly be said that they favor any one face, for they often divide the O faces into trangles. Other striations occur less abundantly which may be referred to the intersection of planes of ∞O with O, seeming to indicate a minor parting. Striations parallel with the edges of O, have been previously noted by Cathrein (Zwillingsbildung am Magnetit, Zeitschr. f. Kryst. xii, 47, 1887), and again by Mügge (Neues Jahrb., 1889, i, 244), by whom they were regarded as polysynthetic twinning on the spinel law, and due to gliding planes. Such twinnings and striations on spinels proper, have been long known (see Strüver, Zeit. f. Kryst., ii, 480) and are noted in most of the mineralogies. On Cathrein's crystals the striations seem especially to favor one face, and this adds weight to the above explanations. The striations on the Lake Champlain crystals are not especially parallel to any one face, but cross each other frequently, and the other striations parallel to ∞O, add some complexity. The beds which contain them have been subjected to great dynamic movements and these partings are very probably due to pressure—which has also developed the fine pseudo-cleavage planes in the massive mineral. If it were allowable to conceive of a chief parting along O, and a rarer one along ∞O, occasioned by such pressure, without any accompanying twinning, I should think it more likely to be the true cause of the phenomena. The massive mineral shows these octahedral parting planes quite as large as the hand.

2.



Geol. Laboratory, Cornell University.

ART. VI.—*Occurrence of Goniolina in the Comanche Series of the Texas Cretaceous;* by ROBERT T. HILL.

FOR several years I have been puzzled by a peculiar organism which occurs abundantly in the basal and medial beds of the Comanche series of the Texas Cretaceous. This organism is preserved in chalky beds of whose lithologic character it partakes, and is about the size and shape of ordinary playing marbles used by boys except that it is slightly elongated, and flattened at one end where there is a circular depression resembling the point of attachment between a fruit and its stem. The surface is minutely pitted or reticulated.

Possessing no library facilities at Austin, I recently sent suites of these fossils to various paleontological friends in the ientific centers of the east, all of whom pronounced them an ndertermined species of the genus Goniolina, of D'Orbigny, ut as to where the genus belonged in the animal or vegetable ingdom, no one felt positive as attested by the following let- er from a gentleman who is considered one of our ablest con- hologists.

"The fossil you send belongs to a group which has puzzled aleontologists for many years, and has been referred to al- ost every obscure group of paleozoölogy and botany. They ere named *Goniolina* by Orbigny, who put them among the oraminifera. Dr. White has shown me a French publication y Dumortier in which a Jurassic species is referred to the *rinoidea;* Zittel says that Saporta has decided that they are he fruit of *Pandanus* or "screw pine." My own opinion is hat they are *fruit* of some kind, and Saporta's reference is the he most likely to be correct. Yours should be Lower Cre- aceous."

The above letter indicates a remarkable diversity of opinion. But I think a brief examination of its place and mode of occurrence will remove this species at least from any suspicion of being the fruit of land vegetation. It begins in the Colorado river section at the first (lowest) fossiliferous horizon in the basal Fredericksburg bed above the Trinity sands, and ranges upward through 450 feet of sediments into the base of the Comanche Peak chalk. There beds in which it occurs are pulverulent chalks and all comparatively deep sea deposits. In the lowest there are slight traces of finest comminuted sand; in the upper, there are no sands or clays, but the strata are all chalky and magnesian. In none of the beds are there lignites, or other traces of land debris, which would probably be the fact if the Goniolina were vegetable, while the molluscan associates of the form are all off-shore species, such as *Monopleura*, *Toxastes*, *Tylostoma* and many other forms. At the horizon of its chief occurrence it is associated with a chalk composed almost entirely of a large foraminifer which Roemer named *Orbitolina Texana*,* and which Meek† later referred to the genus *Tinoporus.*

Zittel‡ refers the genus to the family Cornuspiridæ of the Foraminiferæ and says that it is a Jurassic genus.

Its occurrence in the medial third of the Comanche series—the first noted in America—is of interest, and I shall be glad to furnish specimens to any who desire them.

Austin, Texas, March 5, 1890.

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* Kreidebildungen von Texas, F. Roemer.

† Check List of Invertebrate Fossils of North America, p. 1.

‡ Handbuch der Paleontologie, pp. 75, 110, 728.

ART. VII.—*A Method for the Reduction of Arsenic Acid in Analysis;* by F. A. GOOCH and P. E. BROWNING.

[Contributions from the Kent Chemical Laboratory of Yale College—III.]

HOLTHOFF'S development of Mohr's suggestion relative to the reduction of arsenic acid to the lower condition of oxidation by the action of sulphurous acid,* with the demonstration that arsenic acid can be evaporated even to dryness in presence of hydrochloric acid without danger of significant volatilization, has placed the analysis of ordinary compounds of arsenic, both natural and artificial, within the scope of Mohr's classical and exact method of determination by titration with iodine. As Holthoff left the method, it is satisfactory so far as regards accuracy, and as modified by McCay,† who substitutes for the four hours' digestion heating for one hour in a pressure-bottle, is eminently successful. In the account of the experiments about to be described we detail our experience in an attempt to shorten still further the process of reduction of arsenic acid by making use of hydriodic acid as the active agent instead of sulphurous acid.

In a recent paper‡ we have described a method for the determination of iodine in haloid salts based upon the action of arsenic acid, in the presence of sulphuric acid, according to the equation,

$$H_3AsO_4 + 2H\text{-}I = H_3AsO_3 + H_2O + I\text{-}I,$$

the iodine being completely volatilized, but leaving behind in the arsenious acid produced by the action the record of the amount of hydriodic acid originally present. This reaction we propose to utilize conversely, and to employ potassium iodide in excess, in presence of sulphuric acid, to bring about the reduction of the arsenic acid to arsenious acid which may be determined, after neutralization, by the iodine method. The conditions of the methods are different in that, in the former the hydriodic acid is entirely broken up by the action of the arsenic acid, and the iodine volatilizes easily; while in the latter some hydriodic acid must remain in solution until a very low degree of concentration is reached, and remaining must exhibit its characteristic proneness to retain free iodine.

We find in practice that when a solution made up to contain sulphuric acid, an arseniate and potassium iodide to an amount somewhat in excess of that theoretically demanded to effect the conversion of the arsenic acid to arsenious acid, is boiled, iodine is evolved and the color of the liquid passes from the dark red when the iodine is abundant through the various gradations of tint to a canary yellow, and then, as the sulphuric acid reaches a degree of concentration sufficient to determine by its own specific action the liberation of iodine, the color again darkens, and if the process of concentration is continued, and much arsenic is present, crystals of arsenious iodide separate and form more abundantly on cooling. If evaporation is pushed still farther the arsenious iodide begins to volatilize and at the point where the sulphuric acid fumes the liquid loses all color and the arsenic has vanished more or less completely. In one experiment conducted in this manner it was found, by the method to be described later, that of 0·3861 grm. of arsenic pentoxide originally present with 1 grm. of potassium iodide and 10 cm^3 of sulphuric acid [1:1] the equivalent of 0·1524 grm. remained. In another similar experiment in which, however, only a few milligrams of arsenic oxide were involved not a trace of arsenic remained at the end.

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* Zeit. f. Anal. Chem., vol. xxiii, p. 378.

† Am. Chem. Jour., vol. vii, p. 373.

‡ This Journal, vol. xxxix, p. 188.

It is obvious that two points in this course of action demand examination at the outset. First, means must be found for removing the remnant of free iodine which is withheld by the hydriodic acid; or of rendering it harmless in the titration process to follow; and, secondly, the degree to which the solution may be concentrated without loss of arsenic must be fixed. In our work upon the converse of this process, we noted particularly the marked influence of the amount of sulphuric acid present upon the degree of concentration necessary to expel the iodine. We turned attention, therefore, at once to this point in the present case and investigated the effect of varying the proportion of sulphuric acid in solutions containing definite amounts of potassium iodide and potassium arseniate. The volume of the solution was made up to about 100 cm^3 and concentrated by boiling until the color was faintest. Then, to determine provisionally, and for preliminary purposes, the point at which volatilization of arsenic was likely to occur, the concentration was continued until the arsenious iodide began to separate. The results are tabulated as follows:

KI	As_2O_5	H_2SO_4 [1:1]	Volume when color was lightest.	Volume when AsI_3 appeared.
1 grm.	0·1900 grm.	20 cm^3	80 cm^3	33 cm^3
1 "	0·1900 "	15 "	65 "	25 "
1 "	0·1900 "	10 "	40 "	19 "
1 "	0·1900 "	5 "	30 "	11 "

The amount of sulphuric acid which, considering rapidity in concentrating to the proper point, ease in neutralizing the acid previous to titration, and general convenience in manipulation, seemed to be best was 10 cm^3 of the mixture made by diluting the acid with an equal volume of water. This we fixed upon for use in future experiments and set the limit of concentration at 40 cm^3.

It is manifest from the phenomena described that when much hydriodic acid remains in the solution the last portions of free iodine cannot be completely removed by heat without volatilization of the arsenic. We experimented, therefore, upon the effect of very dilute sulphurous upon the remnant of iodine in liquids constituted as described and concentrated to 40 cm^3, the point of minimum color, the solution of sulphurous acid which we employed corresponding approximately to centinormal iodine. We found that upon adding the sulphurous acid drop by drop to the hot concentrated solution the point at which the color vanished could be determined without difficulty, but that if the solution was permitted to stand a single minute the color of iodine returned, doubtless developed by the action of air upon the hot hydriodic acid. We adopted, therefore, the plan of at once diluting the solution with cold water as soon as the sulphurous acid had done its work and immediately neutralizing with potassium carbonate. When this mode of proceeding was followed we were unable to find evidence of reversion of arsenious acid to arsenic acid, magnesia mixture producing in the solution no precipitate of the ammonium magnesium arseniate.

Following out the same general lines, therefore, we proceeded to the quantitative examination of the process. Portions of a standard solution of the dihydrogen potassium arseniate were measured from a burette into counterpoised Erlenmeyer flasks of 250 cm^3 capacity, and the increase in weight was taken as the measure of the actual amount of the solution employed. Potassium iodide in solution, and 10 cm^3 of sulphuric acid [1 : 1] were added, and the liquid was diluted with water to a volume of about 100 cm^3. A trap made, as described in our paper upon the reverse of this process, by cutting down a two-bulbed drying tube, was hung in the neck of the flask to prevent mechanical loss, and the liquid was rapidly concentrated by boiling until the volume of 40 cm^3, the point at which the color of iodine had faded to a pale yellow, was reached. At this point the flask was removed from the flame, its sides and the trap were quickly washed down, the weak sulphurous acid was added drop by drop from a burette until the color of the free iodine had just vanished, the liquid was immediately diluted with cold water, the free acid was nearly neutralized with potassium carbonate and the point of neutralization was ed and passed a little by the addition of the acid potassium mate. After cooling completely a definite amount of h solution was added and the titration of the arsenious was proceeded with as usual, due correction being made for mount of iodine necessary to produce the end color into olume of liquid and starch solution employed.

e value of the standard solution of the arseniate was fixed o series of determinations. One series was made accord-o Levol's method of precipitating the ammonium magne-arseniate and weighing as the pyroarseniate, modified, ver, in that the precipitate was collected on asbestus in a rated crucible and ignited after moistening with ammo- nitrate. In the second series McCay's modification* of h's method was followed, excepting that the silver arseni-as collected, dried and weighed on asbestus in a perforated ble. The mean of several closely agreeing determinations for the contents of 50 grms. of the solution in arsenic xide as 0·3824 grm. by Levol's method and 0·3830 grm. McCay's modification of Reich's process. We took the of these figures 0·3827 grm. as the standard of the solu-

e details of the experiments with this solution are recorded e following table.

KI ken.	H_2SO_4 [1:1] taken.	As_2O_5 taken.	As_2O_5 found.	Error.	
grm.	10 cm³	0·3861 grm.	0·3862 grm.	0·0001 grm.	+
"	10 "	0·3862 "	0·3856 "	0·0006 "	−
"	10 "	0·3861 "	0·3862 "	0·0001 "	+
"	10 "	0·3860 "	0·3862 "	0·0002 "	+
"	10 "	0·3863 "	0·3862 "	0·0001 "	−
"	10 "	0·3862 "	0·3862 "	0·0000 "	
"	10 "	0·1927 "	0·1922 "	0·0005 "	−
"	10 "	0·1928 "	0·1922 "	0·0006 "	−
"	10 "	0·1930 "	0·1925 "	0·0005 "	−
"	10 "	0·1930 "	0·1927 "	0·0003 "	−
"	10 "	0·1936 "	0·1929 "	0·0007 "	−
"	10 "	0·1929 "	0·1928 "	0·0001 "	−

periments in which smaller quantities of arsenic were led were made similarly, excepting that the standard solu- from which portions for the tests were measured, was by diluting the former standard ten times, and centinor-iodine was used in the titration.

hen the amount of hydriodic acid in solution is small, spondingly small amounts of iodine are retained after

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* Am. Chem. Jour., vol. viii, p. 77.

KI taken.	H_2SO_4 [1 : 1] taken.	As_2O_5 taken.	As_2O_5 found.	Error.
1 grm.	10 cm^3	0·0383 grm.	0·0380 grm.	0·0003 grm. −
1 "	10 "	0·0383 "	0·0385 "	0·0002 " +
0·5 "	10 "	0·0383 "	0·0384 "	0·0001 " +
0·4 "	10 "	0·0383 "	0·0385 "	0·0002 " +
0·3 "	10 "	0·0383 "	0·0386 "	0·0003 " +
0·2 "	10 "	0·0383 "	0·0384 "	0·0001 " +
0·2 "	10 "	0·0076 "	0·0074 "	0·0002 " −
0·2 "	10 "	0·0076 "	0·0074 "	0·0002 " −
0·2 "	10 "	0·0038 "	0·0034 "	0·0004 " −
0·2 "	10 "	0·0038 "	0·0034 "	0·0004 " −

concentration. In the following experiments colorless solutions were obtained and, for the sake of comparison with the previous results, these solutions were neutralized and titrated without treatment with sulphurous acid, there being no apparent need for adding it in these cases.

KI taken.	H_2SO_4 [1 : 1] taken.	As_2O_5 taken.	As_2O_5 found.	Error.
0·2 grm.	10 cm^3	0·0038 grm.	0·0035 grm.	0·0003 grm. −
0·2 "	10 "	0·0038 "	0·0035 "	0·0003 " −

It appears, therefore, that the average error of the whole number of determinations (twenty-four) made by this process amounts to rather less than 0·0002 grm.—, falling between extremes of 0·0003 grm. + and 0·0007 grm.—. The entire amount of arsenic pentoxide handled in the twenty-four determinations was 3·7352 grms., and of this 3·7309 grm. were indicated in the titration as reduced to the arsenious condition. The loss 0·0047 grm.—the entire error of the process—amounts to 0·13 per cent. of the amount taken.

Certain experiments were made to see whether the period of evaporation might not be dispensed with by so modifying the process that the entire amount of iodine set free in the action of the sulphuric acid, the arseniate, and the iodide might be reconverted at once by sulphurous acid to the condition of hydriodic acid. The conversion was apparently successful, but the results of the modification were several per cent below the truth, indicating that the digestion during evaporation, or the removal of the free iodine, or the combined effect of the two, is essential to the completion of the reduction of the arsenic.

The process as we recommend it may be summarized briefly as follows:—To the arseniate in solution are to be added potassium iodide in excess of the amount needed according to the equation to complete the reduction, and 10 cm^3 of half and half sulphuric acid. The liquid is to be diluted to about 100 cm^3 and boiled rapidly (with the precautions of trapping as described) until the volume is decreased to 40 cm^3. The color of free iodine is to be bleached by cautious additions of sulphurous acid (corresponding roughly to centinormal iodine) and instantly diluted with water and neutralized with potassium carbonate, the neutral carbonate at the first and afterward the acid carbonate. The whole is to be cooled and titrated as usual with iodine, using starch as an indicator. Its advantage is in the rapidity with which it may be executed, the whole operation being easily completed in a half-hour.

ART. VIII.—*On the Development of the Shell in the genus Tornoceras* Hyatt; by CHARLES E. BEECHER, Ph.D. (With Plate I).

THE leading embryonal characters of the genus *Tornoceras* have been drawn mainly from results obtained in the study of *Tornoceras retrorsum*, von Buch, and allied species from the Devonian of Germany.* Probably the best study of any one of the species is that given by W. Branco of *T. retrorsum*, var. *typum*, Sandberger.† The adult features have been determined from the type *T.* (*Gon.*) *uniangulare* Conrad, and other closely related forms. Hitherto our knowledge of this species has not been sufficient to give a reasonably full diagnosis of the genus in its developmental relations, and the results of the following study aim to supply the deficiency. The importance of this is evident, as the characters of the type are of prime consequence, and because *T. retrorsum* offers some differences in its development, and apparently belongs to one of the more advanced phases in the evolution of the generic stock. Instead of presenting a gradual growth from its simple nautiliform protoconch through several slightly diverging stages, it exhibits, to a degree, the principle of accelerated development, as will be shown hereafter; while *T. uniangulare* has a more uniform and complete growth, and is probably one of the initial and most primitive species of the genus.

Besides the sutural and tubular development, the material studied illustrates the inception and growth of the surface ornaments, and as these features are rarely found, the principles involved are of more than generic application.

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* Proceedings Boston Society Natural History, vol. xxii, Hyatt: Genera of Fossil Cephalopods, p. 320, 1883.

† Palæontographica, t. 27. Beiträge zur Entwickelungsgeschichte der fossilen Cephalopoden, 1880.

The specific limits of *T. uniangulare* have not been clearly defined, and many of the forms referred to *Parodiceras* (*Gon.*) *discoideum* Hall, are evidently of the former species. A comparison of the type specimens of both with others which have been grouped with them, as figured in the Thirteenth Report, New York State Cabinet, and in vol. v, pt. ii, of the Palæontology of New York, shows that the first species is really the common one, and so far as known, the second is represented only by the original types.*

The adult differences are mainly noticeable in the depth of the air chambers, and in the sutural curves. They can readily be determined by strictly limiting the characters to those first ascribed to each species. *Parodiceras discoideum* is also apparently without the narrow cone at the bottom of the annular lobe, and the ventral saddle is much less depressed.

The material for this paper is a portion of a collection presented to the museum of Yale University, by Thomas G. Lee, M.D. The particular lot containing the *Tornoceras* consisted of several hundred nodular concretions of pyrite of a radiated structure, obtained from the Devonian (Hamilton) shales of Wende Station, Erie County, New York. Most of them preserved an organic nucleus, and about twenty-five species have been identified as belonging to the Trilobita, Cephalopoda, Pteropoda, Pelecypoda, Brachiopoda and Crinoidea.

The test of the trilobites and the shells of the brachiopods are but little altered, while those of the cephalopods and pelecypods are usually replaced by sphalerite, a difference evidently connected with the more soluble nature of the pearly shells of the nuculoids and cephalopods.

By carefully breaking away the outer enveloping volutions of a number of specimens of *Tornoceras*, the early parts of the shell were uncovered, and found to be well preserved, and therefore, suitable for study. The drawings on Plate VIII were made from the microscope, with a camera lucida.

The protoconch (figures 1, 2, Plate I) has an axial diameter of about $1{\cdot}1^{\mathrm{mm}}$ and varies but little from this dimension among several specimens measured. The vertical diameter is a little shorter, so that the general form is that of a prolate ellipsoid. The latera are prominent, and exposed as central bosses in the umbilicus of a young shell.

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* The following list is proposed as corrected references to *T. uniangulare:*
13th Ann. Rept. N. Y. State Cab., p. 98, figs. 6 (bis) (type specimen) and 6?
Pal. N. Y., vol. v, pt. ii, pl. 71, figs. 11–14 (fig. 14=type specimen), pl. 72, figs. 6, 7, pl. 74, figs. 2, 4., vol. vii, pl. 127, figs. 10, 11, 12.

Of these, pl. 71, figs 11, 12, 13; pl. 74, fig. 4 and pl. 127, figs. 11, 12, were referred to *P. (Goniatites) discoideum*, Hall.

At what precise growth stage the umbilicus becomes closed cannot be ascertained from the material studied, but it is evidently open during the formation of several whorls. During the concrescence of the first few air chambers, while the diameter of the tube is diminishing, the tendency of the umbilicus is to enlarge rapidly. Subsequent increase in the tube and the greater involution of the whorls contract it, so that in adult specimens, it is closed, while in large and often senile individuals, a secondary deposit is made about the umbilicus, entirely obliterating it and covering the growth lines of the shell.* Evidently this formation is similar to that deposited by the dorsal lobe of the mantle in *Nautilus pompilius*.

The axial diameter of the embryo shell is somewhat greater than that of several of the succeeding air chambers. Thus, the tube, in its growth, first contracts, and does not assume the regular rate of increase until after the formation of at least the second septum. A cross section at the first septum is transversely subelliptical, slightly arcuate, with a longer diameter two and one-third times greater than the shorter. When a transverse diameter of 1·2^{mm} is reached by the larval shell, the outline of a section is lunate, but the proportions of length and height are not materially changed. A section of the adjacent whorl is still more arcuate, as shown in figure 6, and in an adolescent specimen 11·5^{mm} in diameter it is seen that the diametral relations have become interchanged, and that the outer whorl is elliptical in a vertical direction, and excavated by the inner whorl to nearly half its longest diameter, making the shell in all nealogic and ephebolic stages decidedly compressed in outline (figure 13).

The first septum (figures 1, 2, 4) is moderately concave, and extends nearly to the axis. The suture is simple, being nearly in a single plane, without apparent lobes or saddles. Occasionally, the internal mould shows a siphonal lobe due to the breaking away of the extremely thin filling between the siphon and ventrum, but perfect specimens determine this to be an accidental condition.

In the section represented in figure 12, the first two septa are much thicker than those immediately succeeding, a feature also noticeable on the exterior of the internal mould. Likewise, the first and second air chambers are deeper than the three or four following. With these exceptions, the septa and air chambers are generally uniform in their progression until the adult stage.

It has already been noted that the first septum is extremely simple, without apparent lobes or saddles. In the second septum, there is a well-developed sinus over the siphuncle, forming a rounded ventral lobe, and a broad lateral saddle, with a corresponding, though less prominent, dorsal saddle. The third and following septa present more and more sharply angular ventral lobes, until finally it is further extended by a siphonal fissure in post-nepionic stages. The lateral saddle is not so strongly curved from the fourth to the seventh suture which is quite flat, but in the eighth, a slight retral bend is observable. This evidently marks the inception of the lateral lobe. The septum is now divided into the leading members characteristic of the group, viz: a ventral lobe and saddle, a lateral lobe and saddle, a dorsal saddle and an annular lobe, although the two latter are less strongly marked than the others. Further growth merely serves to emphasize these features, until the nealogic stadium, when the ventral lobe is extended by the siphonal fissure, and a minute cone appears at the bottom of the annular lobe.

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* This feature is well represented in figure 11, Plate 127 of Pal. N. Y., vol. vii, Supplement.

Several specimens of the protoconch give evidence of the presence of the siphonal cœcum, and show that it was probably closely appressed to the ventral wall. Figure 3 illustrates the ovoid marking on the interior of the shell, enclosing two diverging lines which apparently represent the appressed portion of the true cœcum, while the outer curved lines limit the shelly deposit of attachment. The relative diameter of the siphon at the first and for a number of succeeding chambers is much greater than in the mature shell (figures 1, 6, 13). From the beginning, it is situated close to the abdominal wall, and is nearly invariable in its character.

The embryonic shell is very thin, and almost smooth in its earlier portions; then fine revolving lines of granules appear, which become progressively more pronounced and arranged in transverse rows, between which the earliest of the concentric striæ are developed. With the increase in the strength of the striæ, the granules disappear, and are obsolescent before the protoconch is completed (figure 7). The striæ are sharp, elevated, and straight, forming a conspicuous feature of the ornamentation, until in the third or fourth whorl, when they become subdued, and finally are replaced by the fine inconspicuous and often fasciculate lines of growth which are present in the adult shell. No indication of a funnel is shown up to the completion of the first whorl (figure 10), as the striæ continue straight across the ventrum, but in the second (figure 11), the pronounced sinus in the striæ shows that the funnel had developed or, at least, had become of functional importance.

A comparison of the figures of *T. retrorsum*, v. B., var. *typum*, Sand., as illustrated by Branco (*loc. cit.* pl. v. fig. vii), with the present species shows that the former presents a more arcuate first septum, and that the second is comparable with the third or fourth of *T. uniangulare*, clearly indicating that the development has been accelerated by the skipping of at least two phases of growth in the septa. In other characters, the two forms merely indicate differences which are probably only of specific importance, such as the more angular form of the lobes and saddles in *T. retrorsum*, var. *typum*, and the absence of the minute cone at the summit of the annular lobe.

Yale University Museum, April, 1890.

EXPLANATION OF PLATE I.

FIGURE 1.—Protoconch, showing first septum with lateral edges broken. × 18.
FIGURE 2.—Side view of preceding. × 18.
FIGURE 3.—Ventral view of protoconch with one attached air chamber, showing siphonal cœcum. × 18.
FIGURE 4.—Side view of first whorl. × 18.
FIGURE 5.—Ventral view of preceding, showing development of ventral lobe. × 18.
FIGURE 6.—Transverse section of two whorls near the protoconch. × 18.
FIGURE 7.—Ventral side of protoconch, retaining the shell. × 18.
FIGURE 8.—Ventral side of specimen with first chamber, showing surface ornaments and indication of siphonal cœcum. × 18.
FIGURE 9.—Profile of same. × 18.
FIGURE 10.—Surface ornaments on a specimen consisting of a single whorl. × 18.
FIGURE 11.—Four striæ from the second whorl of a specimen showing funnel sinus. × 18.
FIGURE 12.—Vertical section showing septa and air chambers. × 18.
FIGURE 13.—Outline of a half grown specimen. × 3.
FIGURE 14.—A series of developed septa beginning with the first, showing gradual inception and formation of lobes and saddles to the adult period represented by *j*. *a*, *b*, *c*, *d*, represent the 1st, 2d, 3d and 4th septa, while *e* and *f* represent the 7th and 8th respectively. × 9.

Specimens in Yale University Museum, from the Hamilton shales of Wende Station, N. Y., except specimen figure 13, which is from 18-Mile Creek, N. Y.

ART. IX.—*Fayalite in the Obsidian of Lipari*; by JOS. P. IDDINGS and S. L. PENFIELD.

THE Lipari islands have long been celebrated for their acid lavas and pumices; and it was for the purpose of becoming acquainted with their craters and flows of these rocks that one of the writers recently visited this far famed locality. The obsidian flows that terminated the volcanic activity which built up the craters of snow-white pumice stretch their glassy streams down the steep mountain slopes into the sea. Their upper surface presents a rough and forbidding tract of sharp angular blocks, which appear to have suffered very little change since the solidification of the lava. This portion of the obsidian is filled with small gas bubbles that give it a gray color, and a more or less banded and laminated structure.

The inflation was not sufficient to produce pumice, as in the case of the obsidian flow at Obsidian Cliff in the Yellowstone National Park.*

The spherulites and lithophysæ that occur within the lava sheets some distance from their upper surface are small. They are very abundant in places and are distributed irregularly, and also in layers. Occasionally, finely spherulitic bands render the rock lithoidal. The obsidian is jet black, but on thin edges it is very transparent, and the light gray spherulites may be seen at some depth within the rock. The hollow spherulites in the obsidian stream from the Forgia Vecchia on the east side of the island of Lipari are complex-looking bodies. At first glance they appear to be gray, hollow shells with a rudely spherical kernel at the center. Upon closer examination it is seen that the kernel is a highly crystallized spherulite with distinctly radial structure combined with many small globules. The center of the kernel is dense and gray, but the outer portion consists of a bristling mass of acicular crystals, radiating outward, together with the crystalline pellets already mentioned. The same crystals coat the inside of the surrounding shell, and in many places are continuous with those of the kernels, and are evidently the same growth. The shell is dense with a sub-vitreous luster, and has a narrow white band parallel to the inner margin. The amount of space between the kernel and shell varies considerably. In the smaller spherulites there is very little, and the whole body is clearly one spherulite consisting of a central portion with distinctly radial structure, surrounded by concentric shells of slightly different characters. The innermost of these shells is highly crystalline, white and porous, with minute spaces between the acicular crystals. The next shell is dense, gray and sub-vitreous, and is followed by a narrow white one; the outside, broader shell being dense, gray and sub-vitreous. In the larger spherulites the porous zone has become so porous or open that it forms a cavity between the central part of the spherulite and the outer, denser zones.

Within the larger cavities the white pellets are recognizable as spherical groups of tridymite, and with them are associated occasional thin tablets of fayalite, which, however, are not found in all of the spherulites.

A microscopical examination of the spherulites shows that they are beautifully crystallized at the center, the radiating needles being alkali feldspar. Tridymite is also present, in places being clustered in spherical groups of minute crystals. The structure is the same as that observed in some of the lites at Obsidian Cliff, and described in the paper already The outer shells are fibrous, the gray ones being col- y a cloudy material, which is light brown in transmitted nd does not appear to be doubly refracting. The feldspar hroughout the spherulite are variously orientated in the f their elongation, so that they extinguish light between nicols in groups at different angles to the plane of ation, and exhibit no definite dark cross. In this respect e spherulites correspond to those at Obsidian Cliff.

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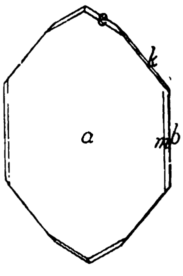
* Obsidian Cliff, Yellowstone National Park, by J. P. Iddings, Seventh Annual Report of the U. S. Geological Survey, 1888, p. 256.

chief interest, however, attaches itself to the fayalite s in the cavities, which have not been noticed heretofore. re not abundant, but occur in several localities, having und by the writer at Forgia Vecchia, and in the obsid- am on Volcano, and having been noted in specimens onte della Guardia on the island of Lipari. In the first ond occurrences just mentioned the fayalite is perfectly nd transparent. In the third it is more or less altered aque.

crystals of fayalite found at Forgia Vecchia are very thin the largest being about 1^{mm} long, 0·5^{mm} wide and less 03^{mm} thick. The habit of the crystals is shown in the panying figure. The forms which were ied are *a*, 100, *i-ī*; *b*, 010, *i-ĭ*; *m*, 110, 21, 2-*ĭ*; and *e*, 111, 1. A slight varia- habit is sometimes caused by the greater pment of the *e* faces. It should be that the prism in this occurrence is *m*, and not *s*, 120, as in the fayalite from n Cliff, Yellowstone Park, and that the lane *c*, 001, is wanting. Very accurate ements of course can not be expected uch very minute crystals, but by em- g a strong illumination and a low ocular lens, δ of y, the following angles were measured on a Fuess goni- , which serve perfectly for the identification of the The calculated angles are derived from the axial ratio hed on the fayalite from the Yellowstone National



		Measured.	Calculated.
a ∧ *e*,	100 ∧ 111	42° 5′	42° 27′
e ∧ *e*,	111 ∧ 1̄11	95° 38′	95° 6′
b ∧ *k*,	010 ∧ 021	41° 2′	40° 49′
a ∧ *m*,	100 ∧ 110	24° 30′	24° 38′
m ∧ *m*,	110 ∧ 1̄10	130° 35′	130° 44′

ge is distinct parallel to *b*, 010. The crystals have a yellow color and show no perceptible pleochroism. In

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Journal, III, xxx, 1885, p. 58, also Seventh Annual Report of the U. S. l Survey, 1888, p. 271.

polarized light they give an extinction parallel to the vertical axis; and in the 45 degree position the thickest crystals exhibit an interference color which is red of the second order. In convergent polarized light an obtuse bisectrix emerges at right angles to a, 100, the plane of the optic axes being parallel to the base. The optical orientation is $\breve{a}=\mathfrak{c}$, $\bar{b}=\mathfrak{a}$ and $\acute{c}=\mathfrak{b}$. Since $\mathfrak{a}$ is the acute bisectrix the double refraction is negative. These optical properties not only agree with orthorhombic symmetry, but also with the determinations made on the Yellowstone Park fayalite.

When treated with hydrochloric acid the crystals are decomposed, and gelantinize. They contain ferrous iron, and after the separation of the iron from solution with ammonia, they yield no micro-chemical reaction for magnesia. Their chemical composition, therefore, is undoubtedly the same as that of the fayalite from Obsidian Cliff, namely: orthosilicate of iron.

The occurrence of fayalite in the hollow spherulites and lithophysæ in the obsidian of the Lipari islands, while not so abundant as in that of the Yellowstone Park, is identical. It is associated in the same manner with tridymite and alkali feldspars, and its development is unquestionably due to the same causes in the two regions.

ART. X.—*On some Selenium and Tellurium minerals from Honduras*; by EDWARD S. DANA and HORACE L. WELLS.

THROUGH the kindness of Mr. Henry S. Durden, of the State Mining Bureau in San Francisco, we have received a number of specimens of minerals containing selenium and tellurium, two of which have proved to be of unusual interest. The presence of selenium in some of them had been already determined by Mr. Charles G. Schneider before they were sent to us, but further than that the examination had not gone. The locality from which they were obtained, as Mr. Durden informs us, is the El Plomo mine, Ojojoma District, Department of Tegucigalpa, Honduras.

The mineral, to which our attention was first directed, proved upon blowpipe examination to contain selenium and tellurium, while the metals proper were absent. It presents itself in massive forms only, with indistinctly columnar structure and shows a perfect cleavage parallel to a prism of 60°. The color is blackish gray, the streak black. It is disseminated through a gangue consisting chiefly of quartz with some barite. An analysis (Wells) of the mineral proved it to contain selenium and tellurium only. The separation of selenium and tellurium was effected by the very convenient method of Divers and Shimosé.* In carrying out this method, it was found that the selenium obtained by a single separation sometimes contained quite a large quantity of tellurium, but the latter could be readily removed by one or two repetitions of the process.

The results obtained are as follows, after deducting 65·68 per cent of gangue consisting of about 43 per cent of silica and 19 per cent of barite with a little gypsum and a trace of alumina:

Se	29·31
Te	70·69
	100·00

The mineral is, therefore, intermediate between selenium and tellurium in composition, and contains these elements in very nearly the ratio of 2 : 3; though we do not attach any importance to the ratio, for the mineral obviously represents simply an isomorphous mixture of these two elements. It is of great interest, however, since it is the nearest approach to native selenium which has yet been found in nature.† The mineral most closely allied to it is a native tellurium from Faczebaja in which Foullon found 6·7 per cent of selenium. It seems to us, therefore, to deserve to be given a somewhat prominent position and we propose to call it *Selen-tellurium*. It is interesting to note here the recent observations of Muthmann‡ showing among other new points the existence of an allotropic form of metallic selenium in hexagonal-rhombohedral crystals, closely isomorphous with metallic tellurium. Our mineral is shown by its hexagonal cleavage to belong with these, as was to have been expected.

Associated with the selen-tellurium are a few minute transparent crystals having a pale yellow color and adamantine luster, which have the appearance of tellurite. The quantity is so extremely small as to make an examination unsatisfactory and we defer the matter in the hope of obtaining additional material.

Quite distinct from the yellow crystals just mentioned, is a greenish yellow mineral which is also obviously an oxidation product and which is present more abundantly. It is best shown in two or three specimens, having the aspect of a quartzose conglomerate and containing patches of a grayish metallic mineral which proved to be nearly pure tellurium. Through this it is scattered in points and narrow veins. It is soft, with hardness from 2 to 2·5 and is easily crushed to powder. The surface, when exposed, is small mammillary and but little structure is discernible even under the microscope, although a tendency to separate into distinct scales is noted. The action on polarized light is very feeble. The mineral is intimately mixed with the gangue and it was only by using extreme care that it was found possible to separate a sufficient quantity of material for analysis, the purity of which could be regarded as beyond all question. This was finally accomplished, however, and an analysis made with the following results. Of the whole amount obtained, viz: 0·32 grams, 0·12 gr. was taken for a water determination and the remainder 0·20 gr. for the other determinations. The results, considering the small quantities used, are very satisfactory. The analysis is as follows:

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* Jour. Chem. Soc., xlvii, 439.

† We pass over Del Rio's unconfirmed statement, in regard to the occurrence of native selenium in Mexico, as not deserving of serious consideration.

‡ Zeitschr. für Kryst., xvii, 356, 1890.

			Ratio.				
Water	7·67 ÷ 18 = ·426		3·55		4·06		4
TeO_2	47·20 ÷ 157 = ·301	·315	2·62	or	3·00	or	3
SeO_2	1·60 ÷ 111 = ·014						
Fe_2O_3	19·24 ÷ 160 = ·120		1·00		1·14		1
Insol.	23·89						
	99·60						

These ratios are not quite exact, but there can be no doubt that it is a normal ferric tellurite of the composition $Fe_2O_3 . 3TeO_2 . 4H_2O$ or $Fe_2 (TeO_3)_3 + 4H_2O$. The slight excess of Fe_2O_3 shown by the ratio very probably comes from the reddish ochreous material associated with it.

The calculated composition, with $\frac{1}{21}$ of the Te atoms replaced by Se, is:

Calculated for Fe_2O_3 $\frac{20}{21}$ TeO_2 + $SeO_2 . 4H_2O$.		Analysis Deducting Insol. Res.	
TeO_2	64·41	TeO_2	62·34
SeO_2	2·28	SeO_2	2·12
Fe_2O_3	22·97	Fe_2O_3	25·41
H_2O	10·34	H_2O	10·13
	100·00		100·00

That the mineral is a ferr*ic* tellur*ite* is evident since it gives off no chlorine when boiled with HCl, nor does it give any reaction for ferrous iron when dissolved in cold HCl.

Two other tellurium-iron minerals have been thus far described: these are Genth's* *ferrotellurite* and the *emmonsite* of Hillebrand.† Our mineral is like ferrotellurite in color, but, if the results of Genth's qualitative trial can be accepted as conclusive, his mineral was a ferrous tellurate, which sepat widely from the Honduras ferric tellurite. Emmonsite ponds in composition more closely, being also a ferric te, and we were inclined at first to think that the two als might be identical. Through the kindness of Dr. rand we have had an opportunity to inspect the original nsite, and furthermore Dr. Hillebrand has made a new cal examination of the scanty amount of material at the results of which are appended to our paper. Our xamination did not extend beyond a microscopic study cleavage plates, but these while confirming the points by Mr. Cross in regard to the cleavages and chief optical ters, proved that in appearance the Honduras mineral mmonsite are widely different. Moreover, Dr. Hille's recent results show that the two minerals differ both io of tellurium to iron, and also in amount of water. Honduras mineral consequently cannot be united with of the minerals named, and although our knowledge of ysical characters is imperfect, the simplicity and exactf the chemical formula shows that it deserves to rank as nite mineral species. We propose, therefore, to call it *enite* after the gentleman to whose kindness we are ed for all the material we have had to use.

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* Proc. Acad. Nat. Sci. Philad., xvii, 119, 1877.

† Proc. Colorado Sci. Soc., ii, 1885.

NOTE ON EMMONSITE BY DR. W. F. HILLEBRAND.

ve attempted a re-analysis of emmonsite with the extremely quantity belonging to Mr. Cross, which he kindly con- to sacrifice for the purpose. Unfortunately the analysis ot entirely successful, but what was done upholds the cor- ss of my former analysis and seems to prove that the two ls are distinct. The weight taken for analysis was ·0764 . The water was determined in this by heating in a boat plug of dry sodium carbonate filling the tube in front, and ing the water in a calcium chloride tube. The weight was ·0032 grams, or 4·2 per cent. This, under the circum- s, is as near as could be expected to my original deter- on (3·28 per cent), which was made on less pure material, ows that emmonsite is distinct from the Honduras mineral, has over 10 per cent of water. After dissolving the mineral, a rather considerable portion of the solution fortunately lost, but the relation of the iron and tellurium at remained was estimated; the result being $Fe_2 : Te =$. This is very near that originally found, i. e., 1 : 3·65. not detect any zinc in this analysis, which is confirmatory opinion formerly expressed that it was present as an ture in some form.

egard to the behavior of emmonsite on heating it may be that even at as low a temperature as 100° C. it becomes brownish, but regains its green color on cooling without having suffered loss in weight. In an unpowdered condition it decrepitates rather violently on further heating, and, as originally stated, fuses readily to a red-brown liquid. In regard to the evidence as to the condition of oxidation of the iron and tellurium in emmonsite afforded by boiling the mineral with hydrochloric acid, I would add that my former experiment was carefully made and the products of distillation were collected in a solution of potassium iodide. No evolution whatever of iodine was observed. While this would not prove the entire absence of a ferrous tellurate, it does prove conclusively, as indicated in my original paper, that the mineral is chiefly a ferric tellurite. This being true, it would be reasonable, even without other evidence, to conclude that the mineral is simply a ferric tellurite and not a combination of ferric tellurite with ferrous tellurate.

Washington, May 31, 1890.

ART. XI.—*On Connellite from Cornwall, England*; by S. L. PENFIELD.

THE rare Cornish mineral, Connellite, was first described as a new species by Prof. Connell, who presented, in 1847, at a meeting of the British Association for the Advancement of Science,[*] a short communication in which he stated that from qualitative tests he had proved it to be a sulphato-chloride of copper containing water. The name Connellite was first given by Prof. J. D. Dana, in the third edition of his Mineralogy, 1850. In the fifth edition of his Mineralogy he also gives a reference to the mineral as early as 1802, by Rasleigh,[†] who calls it a "copper ore of an azure blue color, composed of needle crystals," from Wheal Providence. In 1863 Maskelyne[‡] published a description of the crystals, in which he determined the form as hexagonal, habit slender prismatic, with holohedral pyramidal terminations. Owing to their small size (crystals being not over $\frac{1}{200}$ inch in diameter), he was unable to measure the angle of the terminal faces on the ordinary reflecting goniometer, but by means of a microscope attachment to his goniometer he was able to measure them with a fair degree of accuracy. He identified two prisms, a pyramid of the first order, and a di-hexagonal pyramid. He gives two figures, one of which is copied in the fifth edition of Dana's Mineralogy, the other representing a simpler combination of prism of the second with pyramid of the first order.

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[*] Report of the British Association for 1847. [†] Brit. Min., ii, 13, pl. 12, f. 1, 6.
[‡] Phil. Mag., IV, xxv, 39.

The mineral is one of special interest to the author owing to
apparently close relation to the newly described Spangolite,*
well as the general interest which one always has for such a
re and beautiful mineral, which has been for so many years
entioned and partially described in mineralogical literature.
ortunately Prof. Brush had in his cabinet a specimen of the
ineral, labeled Camborne in Cornwall, which he had obtained
om the Mineralien-Niederlage in Freiberg and which he gen-
ously placed at my disposal. The specimen was composed
iefly of octahedral cuprite, in the cavities of which the con-
llite had deposited, mostly in radiated groups; malachite and
ate were also associated with it. It did not at first seem pos-
ble that enough material could be obtained for making an
vestigation, but on breaking into the specimen additional
vities were found which contained crystals. Owing to the
autiful blue color of the mineral it could readily be distin-
ished from the cuprite, and by careful selecting nearly 0·05
am was obtained on which not the least trace of impurity
uld be detected when examined with a strong magnifying glass.
he specific gravity of two of the pieces was taken in the barium-
ercuric iodide solution, and found to be 3·364. There was,
erefore, the possibility of obtaining still more of the mineral
crushing and sifting all of the material which had been
cked over and separating by means of the heavy solution.
he separation presented some difficulties, as the cuprite was
mewhat attacked by the heavy solution, and the malachite
ried in specific gravity (owing probably to impurities), some
it being almost exactly like the connellite; the mineral was,
wever, separated from the heavier cuprite and lighter agate,
it still contained malachite, from which it was further sepa-
ted by hand picking. The powder was repeatedly brushed
om one watch glass to another and examined in a strong light
ith a lens, so that every bit of malachite which might perhaps
attached to the connellite might be seen and removed. This
peated examination of the powder assured the author that
e material which he had for examination was of exceptional
rity. Altogether 0·074 gram of the pure material was ob-
ined. Before commencing the chemical analysis the crystals
ere carefully examined. The habit agrees well with the gen-
al description of Maskelyne; most of the crystals are slen-
er prismatic, terminated by a pyramid of the opposite order.
rystals are seldom over 0·15^{mm} in diameter, the largest are in
ightly divergent groups, and it was not only difficult to iso-
te a single terminated individual, but also to adjust it on the
oniometer. In three cases the adjustment was made so that
e terminal angle of the pyramid $(10\bar{1}1 \wedge 01\bar{1}1)$ could be

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* This Journal, III, xxxix, 370.

measured with the following results: 49° 26′, 49° 50′ and 49° 42′. The reflections were good, but of course faint, owing to the small size of the faces. Maskelyne gives for the same angle 47° 10′. The zone $2\bar{1}\bar{1}0$, $01\bar{1}1$ and $\bar{2}110$ was also adjusted on the goniometer in which the pyramid was found to be at right angles to the prism of the second order and finally one prismatic zone was measured in which the angles approached very closely to 60°. Using the mean angle of $p \wedge p$ ($10\bar{1}1 \wedge 01\bar{1}1$) $= 49° 39'$, the length of the vertical axis $\dot{c} = 1·3392$ can be calculated. This is probably obtained from more exact measurements than those of Maskelyne. Among the many fragmentary crystals examined under the microscope, the majority had the simple habit of prism and pyramid of the opposite order, a few only showed the combination of prism and pyramid of the same order, while still others were slender and tapering, in habit like an Alston Moor aragonite crystal, but usually terminated at the very end by the ordinary pyramid. No crystals were observed like those described by Maskelyne, showing combinations of the two prisms or a dihexagonal pyramid.

Hardness about 3. Specific gravity as stated above, 3·364. The crystals are transparent and of a beautiful dark blue color, the fine powder is a pale greenish blue. Crystals show under the polarizing microscope parallel extinction and strong positive double refraction, determined on thin prismatic crystals by means of the quartz wedge: they exhibit no perceptible pleochroism, which agrees with the statement of Maskelyne. No distinct cleavage was detected.

The chemical analysis was made with great care on 0·0740 gram. This seems a very small amount for the purpose, but I was prepared to take advantage of the experience which had been gained in the analysis of spangolite, and as no rare or unusual constituents were met with, and as the analysis went on without any mishap I am prepared to place great confidence in the results, which are as follows:

		Ratio.			Spangolite.
SO_3	4·9	·061	1·00		10·11
Cl	7·4	·208	3·42		4·11
CuO	72·3	·911	15·00		59·51
H_2O	16·8	·931	15·34		20·41
Loss at 100° C.	·4			Al_2O_3	6·60
	101·8				100·74
O equivalent to Cl	1·7			O eq. to Cl	·72
	100·1				99·82

The ratio here is not very satisfactory except between SO_3 and CuO, with H_2O slightly in excess. If, however, we assume that some OH is isomorphous with the Cl and calculate enough

o that when added to the Cl it will bring the ratio up to
rst whole number, the analysis will be as follows:

		Ratio.		
SO_3	4·9	·061		1·00
Cl	7·4	·208	·243	4·00
OH	·6	·035		
CuO	72·3	·911		15·00
H_2O	16·5	·913		15·04
Loss at 100° C.	·4			
	202·1			
valent to Cl and OH_1	2·0			
	100·1			

ith this interpretation the ratio is very exact, and from
epeated instances in which Cl and OH mutually replace
nother it seems best to make this assumption to explain
nalysis. The formula can then be written Cu_{16} (Cl . OH)$_4$
$15H_2O$, although it is of course probable that all of the
hich is not in combination with Cl and SO_4 is combined
hydroxyl. The compound is very similar to spangolite
mposition, an analysis of which is given above for com-
on, both minerals being very basic sulphato-chlorides. In
golite, moreover, the closest relation was found between
Al_2O_3 and CuO, while Cl was slightly deficient and H_2O
, and it was also stated in discussing that analysis that the
s could be made almost exact by assuming, as in this case,
a little OH is isomorphous with the Cl. The method of
sis was on the whole like that employed in the analysis of
golite. The air-dry powder lost very little by drying in a
cator over H_2SO_4 or in an air bath at 100° C. For deter-
ng the water the mineral was weighed in a platinum boat,
red with dried Na_2CO_3 and ignited in a combustion tube,
vater being collected in a weighed chloride of calcium
: it was found to be neutral. Before making the experi-
. on the mineral a blank trial was made in which the chlo-
of calcium tube gained only ·0002 gr., showing that dried
O_3 can be handled quickly in the air without taking on
appreciable quantity of moisture. The greatest pains was
with the SO_3 determination: before filtering off the pre-
ated $BaSO_4$ the solution containing the precipitate was re-
edly evaporated with HCl to remove as far as possible all
O_3. After filtering off the $BaSO_4$ the filtrate was again
orated to dryness, taken up in very dilute acid and water
he least trace of $BaSO_4$ filtered off. The $BaSO_4$ precipi-
originally weighed 0·0110 gr. after purifying in the ordi-
way by fusion with Na_2CO_3 and reprecipitating it weighed
3 gr., showing that the first precipitate was nearly pure,
s there is some chance of loss during the manipulation of

so small quantities the first weight was used in the analysis. The very small percentage of SO_3 is certainly remarkable. Finally, the last filtrate, after precipitating the copper with H_2S, was evaporated to dryness, ignited to expel the excess of H_2SO_4, the residue dissolved in water and tested with ammonia, ammonium sulphide, ammonium oxalate and sodium phosphate, but as no precipitates were formed it was assumed that everything had been precipitated from the solution. The weighed AgCl and Cu_2S were found to be pure.

Pyrognostics and chemical tests.—Connellite fuses before the blowpipe at about 2 to a black shining globule, coloring the flame green. Heated in the closed tube it gives abundant water, which has a strong acid reaction. Insoluble in water, but soluble in dilute acids, the solution giving with barium chloride a slight precipitate of $BaSO_4$.

Mineralogical Laboratory, Sheffield Scientific School,
New Haven, May, 1890.

SCIENTIFIC INTELLIGENCE.

I. CHEMISTRY AND PHYSICS.

1. *On the Chemical character of Beryllium.*—In consequence of the position of beryllium as a typical element in the periodic system, KRÜSS and MORAHT have made an exact study of its chemical characters. The oxide was prepared from Arendal leucophane, by acting on the finely pulverized mineral with sulphuric acid in excess, the operation being conducted in a platinum dish. After driving off the excess of acid, the mass was treated with water, and the solution added to one of ammonium carbonate in excess, in which the precipitate at first formed was dissolved. After ten days standing, the filtrate was boiled, whereby a precipitate of beryllium oxide was obtained, containing some alumina and iron oxide. To purify it the beryllia was dissolved in hydrochloric acid, precipitated with ammonia and digested with ammonium carbonate solution, in quantity insufficient for complete solution. The solution after ten days standing was filtered and steam blown through it till almost all the beryllium oxide was thrown down. The last trace of iron was removed by adding ammonium sulphide to the ammonium carbonate solution, allowing it to stand two days, filtering and boiling. The ignited precipitate was snow-white and dissolved in hydrochloric acid yielding a colorless solution. To prepare metallic beryllium the authors at first heated a mixture of the oxide and metallic magnesium in a porcelain crucible; but the beryllium obtained was contaminated strongly with silicon. They then reduced potassium-beryllium fluoride with sodium in a steel crucible, the re-

metal being protected from contact with the crucible. On g the mass with water small hexagonal crystals of beryl-ere obtained mixed with pulverulent metal and oxide. To ine whether beryllium oxide could act as an acid oxide and eryllates the freshly precipitated hydroxide was digested holic solution of potassium hydroxide until it was sat-, care being taken to exclude carbon dioxide. On evapo-over sulphuric acid, a white silky mass was obtained which formula closely approximating $Be(OK)_2$. To determine sicity of beryllium oxide, absolute alcohol was saturated ulphur dioxide gas, and pure, recently precipitated beryl-ydroxide was dissolved in it to saturation. On evaporation ulphuric acid, a white crystalline residue consisting of hexagonal plates was obtained which on analysis corres-l to the formula $BeSO_4$. With boric acid, a borate $)_6$ was obtained.—*Ber. Berl. Chem. Ges.*, xxiii, 727, Mch.

G. F. B.

n the estimation of the Molecular mass of Colloids by the ! of Raoult.—**Sabanéeff** has made a series of experiments ermine the molecular mass of certain colloid substances by of the freezing points of their aqueous solutions. Col-tungstic acid, for example, dried at 200° and containing er cent of water, corresponding to the formula $H_2W_3O_{10}$ requires 2·52 per cent, has a molecular mass calculated he observed lowering of the freezing point, varying be-677 and 995; while that represented by the formula $)_{18}$ is 714. Colloidal molybdic acid forms minute hygro-plates, which dried over sulphuric acid for several weeks ntain 6·99 per cent of water. It dissolves with difficulty er and produces a lowering of the freezing point corres-g to a molecular mass of 620; that required by $(MoO_3)_4$ 576 and that corresponding to tetra-molybdic acid $H_2Mo_4O_{13}$ 594. For glycogen the molecular mass found was as a 585, corresponding to the empirical formula increased ten-$_6H_{10}O_5)_{10}$, which requires 1620. Dried at 115°, however, bstance possesses a molecular mass one and a half times The lowering of the freezing point produced by colloidal acid was so slight that the values obtained all came within nits of observational errors. Colloidal iron hydroxide not be obtained free from chlorine; the purest solution con-; one molecule of $FeCl_3$ to 116 molecules $Fe(OH)_3$. On umption that the molecular mass of the hydroxide is so hat its influence in producing the slight depression of the g point observed may be neglected, the author calculates ie observed data a molecular mass of 300 corresponding formula Fe_2Cl_6 which requires 325.—*J. Russ. Phys. Chem.* 1889, 515; *Ber. Berl. Chem. Ges.*, xxiii, (Ref.) 87, Mch.

G. F. B.

n the Color of Fluorine and on its Spectrum.—**Moissan** has ied the color of fluorine as seen through a platinum tube

50 centimeters long, having its ends closed with transparent plates of fluor spar. Under these circumstances the gas appears of a distinctly greenish-yellow color, less strongly pronounced than that of chlorine and inclining rather more to yellow. If a little water be allowed to enter this tube full of fluorine, hydrogen fluoride is at once formed and the oxygen is set free in the form of ozone, in a condition of such concentration that the contents of the tube become of a deep indigo-blue color. In order to obtain the spectrum of fluorine, sparks were taken in an atmosphere of this gas contained in a platinum tube, between gold or platinum electrodes. In the red region of the spectrum, the author found thirteen well-defined lines having the following wave-lengths: 749, 740, 734, 714, 704, 691, 687·5, 685·5, 683·5, 677, 640·5, 634 and 623. By a comparison of silicon chloride and fluoride Salet had already observed lines of wave-lengths 692, 686, 678, 640, 623, which he attributed to fluorine.—*C. R.*, cix, 937; *Ber. Berl. Chem. Ges.*, xxiii, (Ref.) 140, Mch. 1890.

G. F. B.

4. *On the Preparation of Hydrazine from Aldehyde-ammonia.*—CURTIUS and JAY have described a simple method of obtaining hydrazine from aldehyde-ammonia $CH_3 . CH . OH . NH_2$. By the action of sodium nitrite upon a cold saturated solution of aldehyde-ammonia in water feebly acid, the nitrosoamine of a base $C_6H_{11}O_2 . CH . NH$, which the authors call paraldimine results, the nitroso-paraldimine itself having the formula $C_6H_{11}O_2 . CH . NNO$. If a little moist hydrogen chloride gas be passed into the ethereal solution of this nitrosoamine, it yields paraldimine hydrochloride $C_6H_{11}O_2 . CH . NH . HCl$, in the form of clear colorless needles. These dissolved in ether and treated with silver oxide yield the free base paraldimine as a mobile colorless liquid, with an odor recalling that of paraldehyde, and which solidifies to a mass of crystals in a freezing mixture. By the action of zinc dust and glacial acetic acid on the nitrosamine, amido-paraldimine $C_6H_{11}O_2 . CH . NNH_2$ is formed; and this when boiled with dilute sulphuric acid, yields paraldehyde and hydrazine sulphate:

$$C_6H_{11}O_2 . C \left\{ \begin{matrix} H \\ NNH_2 \end{matrix} \right. + H_2O + H_2SO_4 = C_6H_{11}O_2 . C \left. \begin{matrix} H \\ O \end{matrix} \right\} + N_2H_4 . H_2SO_4$$

By distillation with alkalies hydrazine hydrate is obtained from the sulphate. The nitroso-paraldimine may be converted directly into hydrazine sulphate by the action of zinc dust and sulphuric acid; but the yield is small owing to the fact that the reduction is liable to go too far.—*Ber. Berl. Chem. Ges.*, xxiii, 740, Mch. 1890.

G. F. B.

II. GEOLOGY AND MINERALOGY.

1. *Post-Tertiary Deposits of Manitoba and the adjoining territories of Northwestern Canada;* by J. B. TYRRELL, of the Geological Survey of Canada. (Bulletin of the Geological Society of America.)—The district treated of in this paper com-

es the northern extension of the prairies of Dakota and Mon-
a lying within Canadian territory, and consists largely of the
inage basins of the Saskatchewan and Assiniboine Rivers
tching westward from the Archæan nucleus to the Rocky
untains. This region is almost entirely underlain by clays
sands of Cretaceous or Laramie age. But some Miocene
Pliocene conglomerates, composed of quartzite pebbles from
Rocky Mountains extend as far east as long. 107° 15′, and
se conglomerates furnish a secondary source of supply for
ny of the quartzite pebbles of the drift.

he whole region, with the exception of four of the higher
nts near its southwest corner, is covered with a deposit of till
t varies greatly in thickness, being especially affected by the
ny inequalities in the surface of the underlying older beds.
till is, as usual, an unstratified deposit largely of local origin,
having included in it a considerable amount of material de-
ed from the northeast. In the more western parts of the
adian plains it may be subdivided into two divisions, sepa-
ed by a distinct interglacial formation, showing clear evidence
a retreat and a re-advance of the continental glacier, but for
nitoba proper the evidence of an interglacial period is not
lear.

he fact is also again clearly pointed out that there is a nar-
belt of country stretching along the foot of the Rocky
untains from which the till is absent and which has never
n overridden by the continental glacier.

ntimately associated with the till are a number of terminal
raines similar to those that have been traced out by several
erican geologists in Minnesota, Wisconsin and farther east,
ich appear to extend in approximately parallel lines in a
thwesterly and southeasterly direction across the plains, be-
ning on the east with the Riding and Duck Mountains and
ending westward to the Hand Hills and the western end of
Cypress Hills. No terminal moraine is to be seen along the
stern edge of the till-covered area, but the drift gradually
ns out and disappears. The theory is advanced that isolated
es may, for short intervals of time, have occupied the space
ween the icefoot and the eastern flanks of the mountains, being
nmed in to the north and south by local glaciers moving east-
rd.

he direction of flow of the continental glacier has been traced
to some extent. In the great Lake Winnipeg Valley east of
Duck and Riding Mountains the ice flowed southeastward in
direction of the trend of the valley. A similar remark holds
d for the valley of the Upper Assiniboine River, and it is
te possible that this direction may have been maintained all
way across the plains, the ice leaving the Archæan in a
thwesterly direction, and gradually sweeping round to the
theast. In Lake Winnipegosis many of the islands are stated
be of the nature of Drumlins, lying with their long axes paral-
to the direction of glacial striæ.

The Duck Mountain is shown to be of particular interest as its summit is composed entirely of morainic debris, and after the retreat of the continental glacier the summit of this moraine became itself a collecting ground for the snow from which glaciers flowed down the valleys of the surrounding slopes. A few kames are also recorded as occurring along with this latest stage of glaciation.

Overlying the till throughout extensive areas are stratified alluvial deposits that have been laid down in the beds of extinct Post-glacial lakes. A marked feature of these beds is the absence of fossils of any kind. The positions of some of these lakes is indicated, one or more lying near the headwaters of the Saskatchewan River, one east of the Missouri Coteau, and one on the upper Assiniboine, but the largest occupied the basin of Lake Winnipeg and has been named by Mr. Warren Upham, Lake Agassiz. The shores of this lake have been traced northward to lat. 53°, and how much farther north they extend is not known.

Mr. Tyrrell in answer to questions stated that the evidence at present at hand appeared to indicate that the preglacial drainage of the Winnipeg basin was northward rather than southward, and that the isolated bowlders seen on the surface of the plains had probably been carried to their present position within the ice of the glacier itself, and not beneath it, as had been the case with the great mass of the till.

2. *8th Annual Report of the Director of the U. S. Geological Survey*, 1886-87.—The following are Papers in this Report issued separately.

(1.) *The Trenton Limestone as a source of Petroleum and inflammable gas in Ohio and Indiana;* by EDWARD ORTON. 180 pp.—The Report of Prof. Orton is a full and thorough treatment of the subject of petroleum and gas from the Trenton limestone. The facts are among the marvelous in science, and they are here ably presented and discussed both from a geological and economical point of view. Mr. Orton's paper in the last volume of this Journal is in illustration of one branch of this subject.

(2.) *The Geographical Distribution of Fossil Plants;* by LESTER F. WARD. 300 pp.—Mr. Ward states in his opening sentence that this paper is intended as a contribution to the Sketch of Paleobotany which appeared in the Fifth U. S. G. S. Annual Report. That paper was written as an introduction to a larger work dealing exclusively with the literature of the science, and proceeding primarily from a bibliographical standpoint. This paper continues the subject "without departing from the chiefly bibliographical method," while at the same time bearing on the geographical distribution of fossil plants inasmuch as the bibliography is presented under geographical divisions, commencing with Great Britain. Mr. Ward makes the bibliography historical for each country as regards the developments in paleobotany, gives copious notes on the various works mentioned, and points out the bearing of discoveries in solving the various questions

ve been successively under consideration. The paper has
d a vast amount of labor in its preparation, and will be of
alue to all interested in the department. The localities in
ited States of fossil plants, and the geological periods of
nts of each, are presented in colors on a map.

Geology of the Lassen Peak District; by J. S. Diller.
-Mr. Diller has commenced his study of the geology of
ıcade Range with that of the Lassen Peak district, and
ves an account of the latter region—its general features,
·aphical structure, and upheavals in connection with the
re of the Sierras and their relation to volcanic action in
trict. The formations described are the Auriferous slates,
iferous limestone and serpentine; the Chico beds of the
:ous and the Miocene. The important conclusions with
to the faults and constitution of the Sierras, reached by
ller, are briefly noticed on page 152 of vol. xxxiii of this
l, 1887.

ulletin of the Geological Society of America, vol. 1.—A
the papers published in separate parts constituting the
›lume of the Geological Society of America is given, so
hen issued, on page 402 of the last volume of this Journal.
have also appeared papers by J. B. Tyrrell on the Post-
y deposits of Manitoba and the adjoining territories of
ʼestern Canada (an abstract of which is given on page 38);
Ells, the Stratigraphy of the Quebec Group (reviewed in
volume of this Journal by C. D. Walcott); T. C. Cham-
some additional evidences bearing on the Interval between
ıcial Epochs; H. S. Williams, the Cuboides zone and its
a discussion of methods of Correlation; E. Brainard and
Seeley, the Calciferous formation in the Champlain Valley
supplement on the Fort Cassin Rocks and their fauna by
Vhitfield. The volume closes with the Proceedings of the
Meeting held at New York, December 26, 27, 28, 1889,
f. J. J. Stevenson, Secretary.

titles of the papers and the names of their authors are
ıt indication that the volume is one of unusual importance
.rds American geology, giving a long step of progress to
nce. There are several which would be noticed particu-
this place if space allowed.

ie Salt Range in India.—Dr. Wm. Waagen, in the
's of the Geological Survey of India, Ser. xiii, on the Salt
vol. iv, Part 1, 1889, points out that there is distinct
aphic unconformability in the range at the base of the
iferous. Another unconformability exists above the Neo-
and below the beds containing *Cardita Beaumonti*, to
›eriod the Deccan traps are referred.

*ıe Collection of Building and Ornamental Stones in the
National Museum.* A Handbook and Catalogue, by
: P. Merrill, Washington, 1889 (Rep. Smithsonian Instit.,
}, Part II, pp. 277–648).—The collection of building and

ornamental stones of the National Museum upon which the present work is based numbers nearly 3000 specimens. To a large extent it was brought together through the efforts of the late Dr. George W. Hawes, but his work upon it was interrupted by his early death and it has been taken up and ably prosecuted by Mr. Merrill. With the advantage of this large amount of material the author has prepared a very useful manual of American building stones. He gives the chief localities, the mode of occurrence, method of quarrying and working with numerous illustrations, with notes on the effects of weathering, means of preservation, and other related points. The closing chapter gives a concise summary of similar stones from other countries. A series of appendices give tables showing the specific gravity, strength per square inch, etc., also composition, price, and so on.

6. *Annotated List of the minerals occurring in Canada*, by G. CHRISTIAN HOFFMANN, Montreal, 1890 (Trans. R. Soc. Canada, vii (3), pp. 65–105, 1890).—This is a carefully prepared list of Canadian minerals with notes on the important localities. The species are arranged alphabetically and are about 280 in number. An interesting occurrence noted is that of bournonite from Marmora township, Hastings Co., and Darling township, Lanark County.

7. *On the Hygroscopicity of certain Canadian Fossil Fuels*; by G. CHRISTIAN HOFFMANN, Montreal, 1890 (Ibid., pp. 41–55).—The author has carried through an elaborate series of experiments with a series of Canadian fuels from anthracite to peat, showing the amount of water present in dry coal, in saturated, the loss in dry air, and the amount reabsorbed in a moist atmosphere. Some of the results are shown in the following statements :

Lignites (and peat)	retain	2·5—5·0	p. c.	and reabsorb	10·0—14·5	p. c.	water.
Lignitic coals	"	1·0—2·0	"	"	6·5— 9·0	"	"
Coals	"	0·1—1·0	"	"	1·5— 6·0	"	"

8. *Ninth Annual Report of the State Mineralogist of California*, WILLIAM IRELAN, Jr., for the year ending December 1, 1889. 352 pp. Sacramento, 1890.—Some of the subjects discussed at length in this report are the refining and coining of precious metals by S. Gumbinner; the auriferous gravels of California by J. H. Hammond, with numerous sections and excellent illustrations; river mining by R. L. Dunn; on clays by W. D. Johnston; on pottery by Linna Irelan, etc.

9. *A Course in Determinative Mineralogy*; by JOHN EYERMAN. Easton, Penn., 1890.—This is a brief concise series of tables including chiefly the minerals of economic value, arranged first according to metallic or non-metallic luster and subdivided by blowpipe and chemical reactions. The chemical tests chosen have the advantage that they throw together the species which are allied in composition, e. g., those containing zinc, copper, etc., and hence tend to instruct the student as well as guide him in the determination of species.

). *Giornale di Mineralogia, Cristallografia e Petrografia.*
etto dal Dr. F. Sansoni. Vol. I, Fasc. 1. Milan, 1890.
rico Hoepli.)—Mineralogists will be interested in the estab-
ment of a new journal in Italy devoted to Mineralogy, Crystal-
aphy and Petrography. It is published at Milan under the
editorship of Dr. Francesco Sansoni, of the University of
ia, well known as an active worker. The first number con-
s an exhaustive article by Artini upon the Sardinian leadhill-
with two plates, one by Sansoni upon the crystallography of
eries of organic compounds, and others by Boeris, Tognini
zi, besides notes and reviews.

III. Botany and Zoology.

. *Die natürlichen Pflanzenfamilien*, Nos. 39 and 40.—We
e had frequent occasion to call the attention of our readers to
many excellencies of this comprehensive work under the
orship of Professors Engler and Prantl. These numbers
st at hand justify fully all words of commendation we have
towed upon the treatise. The engravings are clear and very
ing, and, as in previous numbers, for the greater part, original.
önland treats of the Order Candolleaceæ, Höck, of Calycereæ,
Hoffmann, of Compositæ. In No. 40, Wille takes up, with a
d degree of fullness, certain of the lower Algæ.
t gives us pleasure to urge upon our readers the request made
the editors, that persons who possess pictures which exhibit
characteristics of type-plants will kindly lend them for the
pose of having them reproduced as illustrations in the work.

G. L. G.

. *Zoe, a Biological Journal.* San Francisco, published
nthly ($2.00 per annum).—One can hardly help wishing that
founders of this new journal might have fixed upon some
ne more attractive. Aside, however, from its name, this first
nber of the new journal is attractive and promises well.
Restricting our notice to the botanical articles, we may call
ention to the following. Dr. Harkness leads off with a well-
sidered paper on the Nomenclature of Organic Life. His
ws are conservative, and, we may say, conciliatory. We wish
erely that his paper might find a larger circle of readers than
s like to have in the initial number of a new magazine. Mr.
ndegee speaks of an arborescent *Polygala*. In the cañons of
Sierra de Laguna, Lower California, *Polygala apopetala*
quires its greatest development, and becomes a small tree,
ing a trunk and spreading top, and equaling in height the
rounding *Acacias* and *Lysilomas*." Mr. S. B. Parish has the
t part of a paper on the naturalized plants of Southern Cali-
nia. His views in regard to discriminating between native
l naturalized plants are sound, and, if carried out further in his
rk, in subsequent communications, will result in giving us
rmation of the highest value.

Mrs. Brandegee furnishes interesting notes in regard to *Dodecatheon Meadia.* She proposes to place the different forms provisionally under four varietal heads. Mr. Brandegee sends a short note about a forest of "Cardon," the Mexican name for two species of *Cereus,* notably *C. Pringlei.* Mr. Vaslit, speaking of the genus *Crossosma,* is inclined to regard *C. Bigelovii* a depauperate form of *C. Californicum.* The journal contains a brief review of recent literature, and also short but interesting reports of meetings of the California Academy of Sciences, and of the San Francisco Microscopical Society.

It is a pleasure to welcome this carefully edited journal. We hope that it will do for the Pacific coast what is so well done in our nearer west by the Botanical Gazette and by the Bulletin of the Torrey Botanical Club, on the Atlantic coast. G. L. G.

3. *Deep-sea Mollusks and the conditions under which they exist;* by WM. H. DALL. Presidential address before the Biological Society of Washington.—The questions considered by Mr. Dall bear on the characteristics and evolution of deep-sea life, and have great interest, although, as Mr. Dall says, "the exploration of the deep-sea faunas has only begun." The conclusion of Tornoe that carbonic acid exists in the abyssal waters only in combination is questioned on the ground of the common occurrence of eroded shells. It may be questioned also on the ground of animal respiration in the depths, and probably also on that of decomposition, which would make free carbonic acid to be at least temporarily present; and considering that no plants exist sufficient to use up the carbonic acid thus evolved the excess of carbonic acid through the depths in some form must ever be on the increase. Mr. Dall states that of the Mollusks the groups that in shallow waters are phytophagous, live in the deeps chiefly on foraminifera, which they swallow in immense quantities, and he attributes to this the larger size of the intestine, the smaller teeth and jaws, and other characteristics; for there is very little food in a given mass of them in proportion to that in algæ. The carnivorous mollusks are the prevailing kinds; but the abyssal species, Mr. Dall states, may get all the food they want from the pelagic life that descends at death from above, without preying on one another. The shells are not drilled, or otherwise marked with evidence of attack by other mollusks. He gives facts respecting the fishes of the bottom which show that they live on mollusks and make large shell heaps. According to Professor Verrill, sea-urchins have been brought up with shells in their stomachs, and star-fishes with sea-urchins inside; so that depredations are not wholly absent from the deep seas. Mr. Dall observes that in deep-water mollusks the layer of aragonite of the shells are thinner than in those of shallow water; the spines of the Murices more delicate as if it were a character that was fading out because unnecessary; the sculpturing is that which strengthens in order to adapt to the pressure at the bottom; the operculum is generally horny and to a large extent absent; the

ls have often a protective epidermis and probably against car-
o acid. Of the abyssal species in the collections of the
ce, 28 per cent belong to the three families *Pleurotomidæ*,
idæ and *Dentalidæ*. The number of Brachiopods in the
oral, *Archibenthal* (along the continental slopes), and *Abyssal*
s are respectively, 8, 12, 3; of Pelecypods, 98, 114, 31; of
hopods (genera Dentalium and Cadulus), 17, 28, 12; of
tropods, 280, 222, 83. Of these, there are common to all
e areas, 32 Gastropods, 5 Scaphopods, 10 Pelecypods and 2
hiopods. J. D. D.

IV. MISCELLANEOUS SCIENTIFIC INTELLIGENCE.

Le Glacier de Aletsch et Le Lac de Märjelen.—PRINCE
AND BONAPARTE. 26 pp. 4to. December, 1889. Paris.—This
oir is devoted especially to the Aletsch Glacier lake. It
tuated on the left side of the glacier about 800 meters from
Eggischhorn and between this summit and the Strahlhörner.
ng side of the glacier, where the basin is wall-sided on
unt of the melting by the water, the depth is 50 meters.
lake has had frequent discharges in consequence apparently
he movements of the Aletsch glacier. The last took place in
tember, 1887, and was complete in 10 hours. It began on
first by a lowering of the level of 0·15 meter on September 1st,
meter on the 2d, 2 meters on the 3d, and then on the 4th,
whole disappeared. It was half full again on the 19th. The
rded times of earlier discharges are: August, 1885; August,
4; July, 1882; January, 1883, but was full again the next
y; July, 1878; August, 1874; August, 1873, complete in 8
rs; August, 1871; August, 1864; August, 1859; August, 1840;
gust, 1820; August, 1813. Partial changes occurred also at
r times. The discharge of the lake is a great calamity for the
ey of the Rhone, which valley the waters reach near Brigue.
waters descend usually without a previous warning, and
y destruction to the cultivated fields on the way. The basin
he lake is an old moraine. At high water the height of the
is 2367 meters; its area is 552,400 meters square.

is proposed to lower the lake 12½ meters by a canal taking
waters above this level—rather more than half—into the
ey of the Viesch. This would diminish greatly, but not pre-
t, the flood from a sudden discharge.

Stone implement at New Comerstown, Ohio.—Much inter-
is excited in Northern Ohio by the recent discovery of a
cal paleolithic implement in the glacial terrace of the Tus-
was River at New Comerstown, Ohio. The implement is
le of the peculiar black flint which occurs in the "Lower
cer" limestone of that region, and is four inches long, two
e, and one and a half thick at the larger end, and chipped on
sides all around the edge. The discovery was made by Mr.
C. Mills, of New Comerstown, on Oct. 27, 1889. But its sig-

nificance was not fully understood until a visit to the place by Professor G. F. Wright and a party of friends from Cleveland on the 11th of April. The glacial terrace is here thirty-five feet above the flood-plain of the river, and the implement was found by Mr. Mills in undisturbed gravel fifteen feet below the surface. Additional interest pertains to this discovery because of the previsions made by Mr. Wright of such discoveries in this valley immediately after his survey of the region in 1881, and reported at considerable length in this Journal, July, 1883, p. 44.

3. *Knowledge, an illustrated Magazine of Science, simply worded, exactly described.* 20 pages 4to.—An excellent periodical, popular but accurate in its science, and fully illustrated. The number for May contains a paper by R. Lydekker, on pouched mammals, well illustrated, and one by A. C. Ranyard, on the great bright streaks which radiate from some of the larger lunar craters, illustrated by an admirable photo-engraved plate from a photograph taken with the great Refractor of the Lick Observatory, besides others of much interest, with book notices and miscellaneous notes.

4. *L'Exposition Universelle,* HENRI DE PARVILLE—Causeries scientifiques, découvertes et inventions; Progrès de la Science et de l'industrie. Vingt-neuvième année—694 pp. Paris, 1890 (J. Rothschild).—This volume gives a very full and instructive account of the French Exposition of 1889. From its first inception to its final completion nothing is overlooked, and throughout the whole book there is a clearness of presentation and profuseness of excellent illustrations which could have hardly had their origin outside of Paris.

Professor Richard Owen.—A letter to the editors from Professor G. C. Broadhead of Columbia, Missouri, states that Professor Richard Owen was assistant to Professor Norwood on the Survey of Wisconsin, Iowa and Minnesota during the year 1849, and immediately after became Professor in the Western Military Institute, located at Drennon Springs, Kentucky. About 1854, the school was transferred to Nashville, Tennessee. Mr. Owen was Professor of the Natural Sciences in the School and as such taught Chemistry, Geology and some Zoology, but also German and Spanish, besides acting as officer in a military capacity and teaching fencing.

Binney's Terrestrial Air-breathing Mollusks. A third supplement to the 5th volume, with 11 plates, has been published as Bulletin No. 4, vol. xix, by the Museum of Comparative Zoölogy, Cambridge.

Geological Survey of New Jersey, Annual Report for 1889. Also vol. ii, Part 1, of the Final Report; containing lists of the Minerals and Plants of the State.

Bulletin No. 2 (vol. i), from the Laboratories of Natural History of the State University of Iowa, contains (1) on the Anatomy of the Gorgonidæ with 10 plates, by C. C. Nutting, and (2) a Catalogue, with notes of the Native Fishes of Iowa, by Seth E. Meek.

Fig. 1.

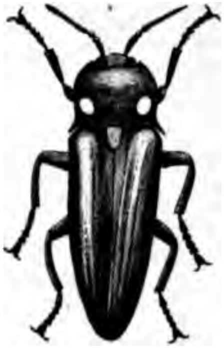
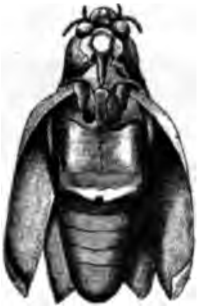
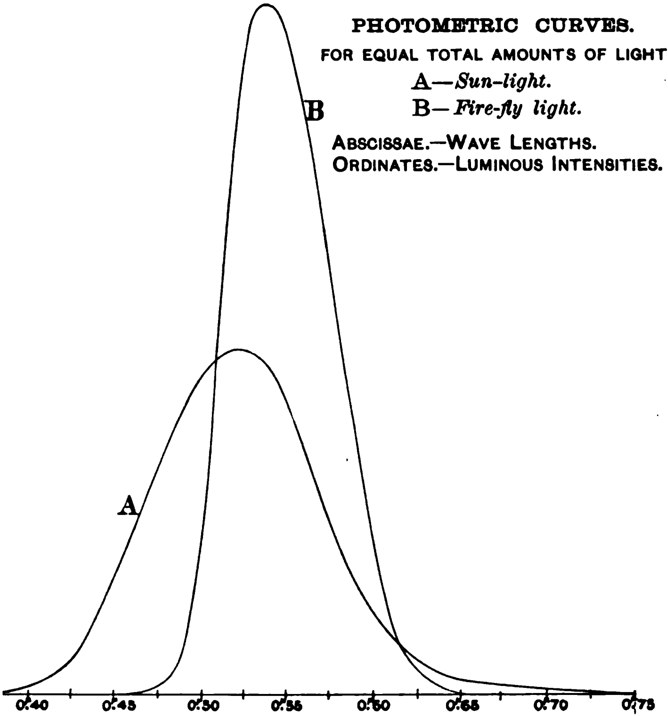


Fig. 2.



PYROPHORUS NOCTILUCUS.



PHOTOMETRIC CURVES.

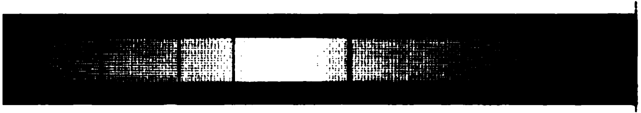
FOR EQUAL TOTAL AMOUNTS OF LIGHT.

A—*Sun-light.*

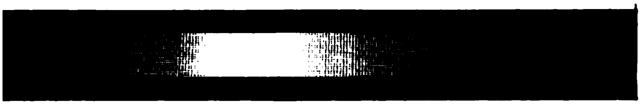
B—*Fire-fly light.*

ABSCISSAE.—WAVE LENGTHS.

ORDINATES.—LUMINOUS INTENSITIES.



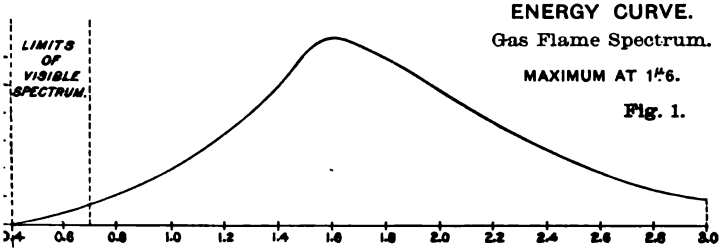
A. *Sun-light Spectrum.*



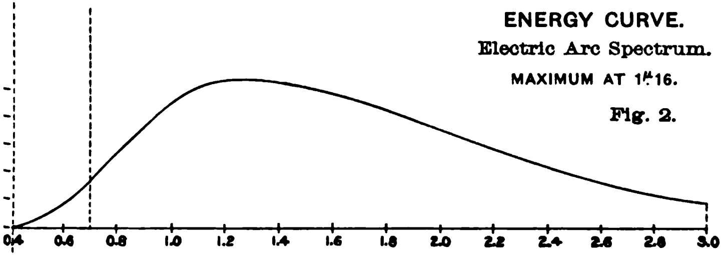
B. *Fire-fly Spectrum.*

Four Curves of Equal Areas, showing one unit of heat displayed successively in heat spectrum of Gas, Electric Arc, Sun and Fire-Fly.

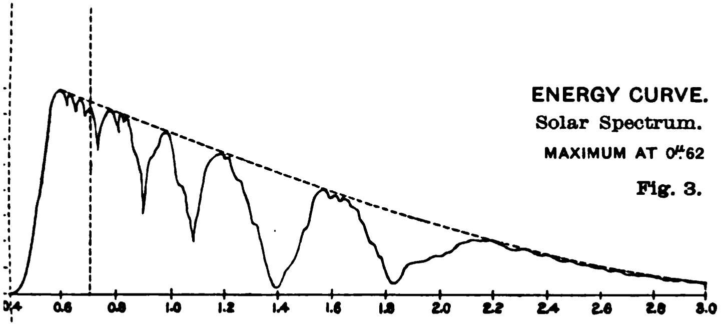
ABSCISSAE.—WAVE LENGTHS.
ORDINATES.—ENERGY AS HEAT.



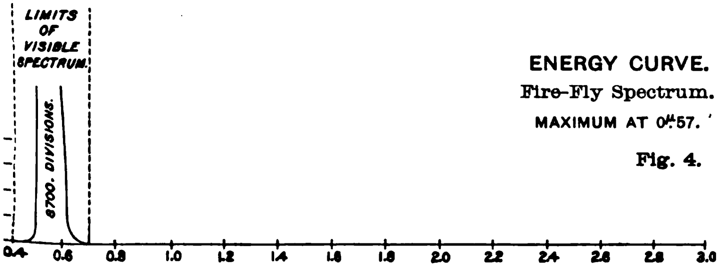
ENERGY CURVE.
Gas Flame Spectrum.
MAXIMUM AT $1^{\mu}.6$.
Fig. 1.



ENERGY CURVE.
Electric Arc Spectrum.
MAXIMUM AT $1^{\mu}.16$.
Fig. 2.



ENERGY CURVE.
Solar Spectrum.
MAXIMUM AT $0^{\mu}.62$
Fig. 3.



ENERGY CURVE.
Fire-Fly Spectrum.
MAXIMUM AT $0^{\mu}.57$.
Fig. 4.

THE

MERICAN JOURNAL OF SCIENCE

[THIRD SERIES.]

T. XII.—*On the Cheapest Form of Light, from studies at the Allegheny Observatory;* by S. P. LANGLEY and F. W. VERY. (With Plates III, IV and V.)

THE object of this memoir is to show by the study of the liation of the fire-fly that it is possible to produce light witht heat other than that in the light itself; that this is actually ected now by nature's processes; and that these are cheaper an our industrial ones in a degree hitherto unrealized. By heapest" is here meant the most economical in energy, ich for our purpose is nearly synonymous with heat; but a given amount of heat is producible by a known expendire of fuel at a known cost, the word "cheapest" may also re be taken with little error in its ordinary economic applition.

We recall that in all industrial methods of producing light, ere is involved an enormous waste, greatest in sources of low mperature, like the candle, lamp, or even gas illumination, here, as I have already shown, it ordinarily exceeds 99 parts the 100; and least in sources of high temperature like the candescent light and electric arc, where yet it is still immense d amounts even under the most favorable conditions to very uch the larger part.

It has elsewhere* been stated that for a given expense at ast one hundred times the light should in theory be obtainle which we actually get by the present most widely used methods of illumination. This, it will be observed, is given as a minimum value, and it is the object of the present research to demonstrate that not only this possible increase but one still greater is actually obtained now in certain natural processes, which we know of nothing to prevent our successfully imitating.

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* See results of an investigation by S. P. Langley, read before the National cademy in 1883, and given in "Science" for June 1, 1883; where it is shown at in the ordinary Argand burner gas flame indefinitely *over* 99 per cent of the diant energy is (for illumination purposes) waste.

It is now universally admitted that wherever there is light, there has been expenditure of heat in the production of radiation existing in and as the luminosity itself, since both are but forms of the same energy; but this visible radiant heat which is inevitably necessary is not to be considered as waste. The waste comes from the present necessity of expending a great deal of heat in invisible forms before reaching even the slightest visible result, while each increase of the light represents not only the small amount of heat directly concerned in the making of the light itself, but a new indirect expenditure in the production of invisible calorific rays. Our eyes recognize heat mainly as it is conveyed in certain rapid ethereal vibrations associated with high temperatures, while we have no usual way of reaching these high temperatures without passing through the intermediate low ones; so that if the vocal production of a short atmospheric vibration were subject to analogous conditions, a high note could never be produced until we had passed through the whole gamut, from discontinuous sounds below the lowest bass, up successively through every lower note of the scale till the desired alto was attained.

There are certain phenomena, long investigated, yet little understood, and grouped under the general name of "phosphorescent" which form an apparent exception to this rule, especially where nature employs them in the living organism, for it seems very difficult to believe that the light of a fire-fly, for instance, is accompanied by a temperature of 2000°, or more, Fahr., which is what we should have to produce to gain it by our usual processes. That it is, however, not necessarily impossible, we may infer from the fact that we can by a known physical process, produce a still more brilliant light without sensible heat, where we are yet sure that the temperature exceeds this. No sensible heat accompanies the fire-fly's light, any more than need accompany that of the Geissler tube, but this might be the case in either instance, even though heat were there, owing to its minute quantity, which seems to defy direct investigation. It is usually *assumed*, with apparent reason, that the insect's light is produced without the invisible heat that accompanies our ordinary processes, and this view is strengthened by study of the fire-fly's spectrum, which has been frequently observed to diminish more rapidly toward the red than that of ordinary flames.

Nevertheless, this though a highly probable and reasonable umption, remains assumption rather than proof; until we n measure with a sufficiently delicate apparatus the heat hich accompanies the light and learn not only its quantity, t what is more important, its quality. Apart from the entific interest of such a demonstration, is its economic value, hich may be inferred from what has already been said. I ve therefore thought it desirable to make the light of the e-fly the subject of a new research, in which it is endeavored make the bolometer supplement the very incomplete evince obtainable from the visible spectrum.

As we may learn from elementary treatises, phenomena of osphorescence are common to insects, fishes, mollusks, vegebles, and organic and mineral matter. Among luminous sects the fire-fly of our fields is a familiar example, though her of the species attain greater size, and perhaps greater trinsic brilliancy, especially the *Pyrophorus noctilucus* Linn., und in Cuba and elsewhere. Its length is about 37^{mm}, width ^{mm}, and it has, like Pyrophori, three light reservoirs—two in e thorax and one in the abdomen. To procure this Cuban e-fly I invoked the aid of the Smithsonian Institution, and rough the kindness of Professor Felipe Poey, of Havana, and ñor Albert Bonzon, of Santiago de Cuba, in the Island of uba, living specimens of the *Pyrophorus noctilucus* were ceived here during the summer of 1889. I have also to knowledge my obligations to Professor C. V. Riley and to rofessor L. A. Howard, to whose knowledge and kind care I n doubly indebted.

After a preliminary spectral examination in Washington, I und it more convenient to continue the research at the Alleeny Observatory by means of the very special apparatus supied by the liberality of the late William Thaw of Pittsburgh, r researches in the lunar heat-spectrum.[*] Photometric easurements throughout the spectrum of the insect's light ere also made.

I have indicated the steps of the investigation, but the exriments have been so largely and so intelligently made by r. F. W. Very, that it is just to consider him as an associate ther than an assistant in the researches. I shall accordingly what follows not discriminate between what each has conibuted.

HISTORICAL NOTES.

We make no attempt to give any bibliography of the subct, and these notes are confined to what seems important in e history of the physical side of it.

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[*] Described in the Memoirs of the National Academy, vol. iv, Part II, p. 112.

Nathaniel Hulme.[1]—Exper. 6. A dead shining glow-worm was put upon water, contained in a wide-mounted phial, at the temperature of 58. The phial was then sunk in boiling hot water, and as the heat communicated itself to the contents of the phial, the light of the glow-worm became much more vivid.

Exper. 7. Another lucid dead glow-worm was put into warm water, at 114, to see if that degree of heat would extinguish the light; but on the contrary its glowing property was augmented. All the water was then poured off, yet the insect continued to shine for some length of time.

Exper. 8. Two living glow-worms were put into a one ounce phial, with a glass stopple; and though they were perfectly dark at the time, yet if the phial was briskly rubbed with a silken or linen handkerchief, till it became pretty warm, it seldom failed to make them display their light very finely. This experiment was very frequently repeated. It had the same illuminating effect upon the light of a dead glow-worm.

Exper. 9. The complete influence of 212 degrees of heat was now applied to the light of a glow worm, by pouring upon one when dead, but in a luminous state, some boiling water. Its light was instantly extinguished thereby and did not revive. The experiment was repeated and with the same result.

Macaire[2] (quoted by Becquerel) found that the luminous matter taken from the body of a glow-worm and heated, increased in brilliancy up to a temperature of about 41° C., after which the light diminished, became reddish and ceased at 52° C. An electric current increased the luminosity in both the living insect, and in the luminous part separated from the remainder of the body, but ceased to have any effect in a vacuum. Oxygen and carbon monoxide increased the light of the living insect and of the luminous matter taken from its body, but the light ceased in a vacuum, in hydrogen, in carbon dioxide, in sulphurous anhydride, and in sulphureted hydrogen.

Carus[3] observed that the luminous matter taken from the body of the glow-worm ceases to shine when dried but glows again when moistened.

Matteucci[4] found that the phosphorescent substance of the Italian glow-worm (*Lampyris Italica*) soon ceased to glow in hydrogen or in carbon dioxide, but shone decidedly brighter in oxygen than in air, the oxygen being consumed and carbon dioxide appearing. He drew the conclusion that the production of light in this insect is entirely due to the combination f oxygen with carbon which is one of the elements of the hosphorescent matter. The greatest brilliancy occurred at a emperature of 37° or 38° Cent., but all phosphorescence ceased bove 50° or below −6° Cent.

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[1] Philos. Trans., Roy. Soc.. London, vol. xc, p. 180–181, 1800.

[2] "Bibliotheque Univ. de Genève." 1821.

[3] "Analecten zur Natur- und Heilkunde," Leipzig, 1829; see also Comptes Rendus, lix. p. 607, 1864.

[4] "Ann. de chim. et de phys.," III, ix, p. 71, 1843, also in C. R., xvii, p. 309.

Robert[1] found that a glow-worm cut in halves continued to low for half an hour, when the light ceased, but commenced gain on the near approach of a candle, and continued as bright s ever for thirty-six hours, after which it was impossible to enew it.

Pasteur[2] has examined the spectra of our Pyrophorus withut finding any appearance of bright or dark lines. He states hat M. Gernez has made a similar observation on the specrum of the glow-worm.

Becquerel[3] gives a good summary of the results of previous bservers. Since phosphorescent solids give banded spectra nd thus differ from ignited solids and liquids which have coninuous spectra, M. Becquerel concludes, from the apparent ontinuity of the spectrum of the light from phosphorescent nimals, that their light approaches nearer to that of ordinary ncandescence,—a deduction which the following result renders nnecessary.

C. A. Young[4] states that the "common" fire-fly gives a ontinuous spectrum, extending from a little above Fraunhofer's line C in the scarlet, to about F in the blue, gradually fading out at the extremities. He observes that it is noticeble that precisely this portion of the spectrum is composed of rays, which, while they more powerfully than any others ffect the organs of vision, produce hardly any thermal or ctinic effect. In other words very little of the energy expended in the flash of the fire-fly is wasted.

(This is a most important and interesting inference, but it will be observed that this is necessarily rather assumed as highly probable than actually demonstrated, since the method did not permit the dealing with the invisible rays except by inference.)

It is quite different with our artificial methods of illumination. In the case of an ordinary gas light, experiments show that at most, one per cent of the radiant energy consists of *visible* rays, the rest being invisible heat; that is to say over ninety-nine per cent of the gas is wasted in producing rays that do not help in making objects visible.[5]

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[1] C. R., xvii, p. 627, 1843.

[2] C. R., lix, p. 509. 1864.

[3] "La lumiere," 1867.

[4] The American Naturalist, Salem. 1870, vol. iii, p. 615.

[5] S. P. Langley has shown that the waste is in fact even greater than this; ee "Science," vol. i, No. 17, p. 482, 1883.

Secchi[1] at first thought that the spectrum of the glow-worm was monochromatic, but with an improved spectroscope, recognized that other colors were present, though feebly and decided that the spectrum was sensibly continuous.

Quatrefages,[2] in connection with the paper of Secchi, remarks that the previous observations of Spallanzani and Macaire, repeated with much care by Matteucci and Becquerel, show beyond doubt that the light of glow-worms and elaters is due to slow combustion. Thus the light is extinguished in a vacuum, and in irrespirable gases, it reappears in contact with the air, it is perceptibly increased by the presence of pure oxygen, it persists after the death of the creature, and finally it is accompanied by the generation of carbon dioxide. Nevertheless he points out that there is a distinct kind of phosphorescence in the marine Noctilucidæ, due to the contraction of muscular fiber, the shining tissue being seen through the translucent body wall. This species of phosphorescence is increased by irritants, but is independent of the presence of oxygen and is not extinguished or in any way modified by hydrogen or by carbon dioxide.

Robin and *Laboulbene*[3] find the luminous organs of *P. noctilucus* composed of irregularly polyhedral cells, $0{\cdot}04^{mm}$ to $0{\cdot}06^{mm}$ thick, between which pass very numerous fine tracheæ and nerves. The inner face of the organ is composed of adipose tissue, and the outer of a transparent modification of the ordinary chitinous covering of the insect. The authors conclude that the light is due to chemical decomposition of a nitrogenous body with formation of crystalline urates.

Jousset de Bellesme[4] finds that although the phosphorescent cells, when separated from the body of the insect, continue to glow for several hours, yet if crushed they instantly lose their illuminating power, which indicates that for the production of the light, the living cells must retain their integrity, and that they are not mere reservoirs of a phosphorescent substance, but continuous generators of it. He surmises that the light-giving substance may be phosphureted hydrogen.

Meldola[5] is quoted by Spiller[6] as having examined the glow-worm spectrum and determined its approximate limits.

Conroy[7] finds the glow-worm's light green, and in a small direct vision spectroscope showing a continuous spectrum from C to *b*, appearing like a broad band of green light extending from $0^{\mu}{\cdot}518$ to $0^{\mu}{\cdot}587$ with a faint continuous spectrum into the red to $0^{\mu}{\cdot}656$.

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[1] C. R., lxxv, p. 321, 1872.

[2] C. R., lxxv, p. 322, 1872.

[3] C. R., lxxvii, p. 511, 1873.

[4] C. R., xc, p. 318, 1880.

[5] "Proc. Entomological Soc.," p. iii, 1880.

[6] "Nature," vol. xxvi, p. 343.

[7] "Nature," vol. xxvi, p. 319, 1882.

?. *DuBois.*[1]—Perhaps the most important of previous moirs on phosphorescent insects is by this writer. It con- ıs an account of photometric measures in wave-length scale, . also of heat measures with the thermopile. The latter resent the only attempt even, in this direction, I know of, seem to be judiciously made but to be insufficient (on ount of the limitations of such apparatus) to establish the hor's conclusion that the light is accompanied by no sensi- heat. This conclusion, we repeat, though very probably rect, does not seem to rest on the evidence of an apparatus at all the necessary sensitiveness. This memoir, however, ears to be in general an excellent one, and well worthy the dent's attention.

rom all these statements it is abundantly clear that not y physicists and chemists, but naturalists, have been led to clude that this light is not associated indissolubly with any alled vital principle or vital process, but it is a result of tain chemical combinations, and that nothing forbids us to pose it may be one day produced by some process of the oratory or manufactory. With this conclusion in mind, we v proceed to observations meant to demonstrate the fact t this process (presumably discoverable but still unknown) es light without invisible heat.

hese observations are: 1. Photometric. 2. Thermal.

PART 1.—PHOTOMETRIC OBSERVATIONS.

he first impression on viewing the light of the *Pyrophorus* *tilucus* through a spectroscope is that it consists essentially a broad band in the green and yellow, while with precaution see this extending into and beyond the borders of the blue l orange, but not very greatly farther, and these have been en by previous observers as its absolute limits. No one ears to have experimentally and distinctly answered the stion, "Would the light not extend farther were it bright ugh to be seen?" nor has it been proven as clearly as might desired that the result depends on the quality rather than quantity of the light, or given conclusive evidence, that if light of the insect were as bright as that of the sun it ald not extend equally far on either side of the spectrum.

t is impossible to increase the intrinsic brilliancy by any ical device, but if it be impossible to make the light of the ect as bright as that of the sun, it is on the other hand quite sible to make the light of the sun no brighter than that of insect, and this would appear to be the first step in obtain- a definite proof that the apparently narrow limits of the ect's spectrum are due to the intrinsic quality of the light and not to its feeble intensity. The only conclusive method of determining this would appear to be to balance the light from the insect with that of a definite portion of sunlight by any ordinary photometric device; and having taken this sunlight as nearly equal as possible to that of the insect, though certainly not greater, to let this determined quantity fall on the slit of a spectroscope at the same time with the light from the insect, two spectra being formed one over the other in the same field and at the same time.

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[1] "Bulletin de la Société Zoologique de France," parts 1, 2 and 3, 1886.

The actual doing this is not so easy as it might appear, owing to experimental difficulties connected with the insect, a part of which arises from the fact that its light is not only fitful but unequal, being of very varying intensities when not wholly intermittent.

The simplest way in which the experiment can be performed is perhaps the following:

The insect is placed immediately in front of the slit of a spectroscope so that the light of its thoracic or abdominal portion falls upon the slit. This forms a narrow spectrum which should be brought into the lower or upper half of the field, the insect being attached to the spectroscopic apparatus in a position as nearly fixed as possible. The spectroscope is now placed with the axis of its collimator in the line of a ray of sunlight cast from a heliostat without. In the path of this ray is a screen with a circular diaphragm covered with ground glass; a lens in front of the slit casts on one portion of it an image of the white circle formed by the ground glass, which image is the same size as the illuminating organ of the insect and forms a spectrum of the same height in the reserved portion of the field. A suitable disposition of lenses placed between the glass screen and the siderostat enables any degree of illumination to be given to the former, from full sunlight to nearly absolute darkness. If the normal spectrum be studied, a grating is selected of such open ruling that the entire visible spectrum of the first order can be seen in the field, but the grating is first so placed that what is seen is not the spectra but the reflected image of the slit, the grating thus acting (at first) the part of a mirror; so that the observer first sees the two circles of light of approximately equal size and brilliancy, one formed by the insect, the other by the sunlight, and the light of this latter, by the arrangement of lenses between the screen and the siderostat is then adjusted so that while remaining of the size of the insect, it is judged to have the same intrinsic brilliancy; or at any rate, not a superior one.

The essential thing is that a photometric comparison shall be made of the two lights before the spectra are formed, and hat under these conditions the sunlight is equal but not supeior to that of the insect.

The necessary condition of equality of the two lights from which the spectra are to be formed, having thus been secured, he grating is moved until the two spectra are brought into he field. The result of this direct test is that the solar specrum when intrinsically of the same brightness, or even when learly of less brightness than that of the insect extends somewhat further toward the red and distinctly further toward the violet, the insect light being more intense than that of the sun or equal lights in the green, but ending more abruptly on the violet side.

It may be added that when the insect's light grew brighter, he increment appeared to be more in the blue end or as if the average wave-length diminished, with the intensity, but there was not opportunity to put this beyond doubt.

Photometric observations in the prismatic spectrum were made previously to the adoption of the arrangement above detailed, the first being on July 1, 1889, using thoracic light. The insect was mounted on an adjustable stand to which it was attached loosely, so as to give it such freedom of motion as s needed to ensure its emitting the light. It was consequently necessary to re-adjust its position incessantly, and this necessity constitutes a very obvious difficulty. The thoracic light spots are two ovals, each about 2^{mm} by $1{\cdot}5^{mm}$ (see Plate III, fig. 1). Their light is not so bright as the abdominal light, but much steadier, and like that, of a decidedly greenish hue. One of these oval spots was placed over the center of a slit, open just enough to receive the light, or about $1{\cdot}5^{mm}$. This slit was in the focus of a glass lens of 8^{cm} aperture and 82^{cm} focus, which acted as a collimator. The prism was a very large one of flint (faces $11{\cdot}5^{cm}$ high, $10{\cdot}5^{cm}$ wide), whose mounting ncluded an automatic minimum deviation attachment. The observing lens was similar to the collimator, with a low-power eye-piece in whose field was a pair of heavy vertical parallel wires. The whole was mounted on the spectrometer, primarily designed for bolometric measures and fully described elsewhere.* The insect turned so as to show the abdominal light s depicted in Plate III, fig. 2, the form of this latter organ on the enlarged scale in Plate III, fig. 3.

The observer waited for some time in a wholly darkened room, and to the eye thus rendered sensitive, the visible spectrum, before magnification, was about 2^{mm} high and 20^{mm} long, he parallel wires being distinctly visible in the indigo at a etting of 45° 25′, corresponding to a wave-length of $0^{\mu}{\cdot}468$, and in the red at 43° 53′, corresponding to $0^{\mu}{\cdot}640$. The spectrum then was visible from a little beyond F to near C, or through a range of $0^{\mu}{\cdot}172$. As might have been anticipated from the greenish color of the light, the maximum brilliancy was in the green near E, or near wave-length $0^{\mu}{\cdot}53$.* From this point the light fell away on both sides more rapidly than in the solar spectrum. (See Plate IV, A, B.)

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* See this Journal, March, 1883, p. 188.

July 2. A comparison of the spectra of the thoracic and of the abdominal light gave the latter upon the average about double the intrinsic brightness of the former. This was only a crude estimate, but more exact methods under the limited time for experiment would have been useless, owing to the very fluctuating character of the light. In continuation of the photometric measurements of the preceding day on the thoracic light, this was compared with that from the flame of an ordinary Bunsen burner at its greatest luminosity, whose area was limited by a diaphragm to that of the size of the thoracic light. The light from the base of this luminous flame (height of flame about $3{\cdot}5^{\rm cm}$, air shut off at base of burner) gave a continuous spectrum, which in these first comparisons was alternated with that of the insect. The spectra were judged to be equal in the blue and the red, but that of the insect was much brighter in the green. Again, a spectrum being formed from light taken midway between the base and point of the flame was found to be everywhere too bright, but especially so in the red.

July 3. Continuation of photometric measures but with abdominal light. (An outline of the abdominal luminous organ is given in Plate III, fig. 3.)

				μ	
Wires seen in	indigo	45°	29′	0·463	Abdominal light.
" "	red	43	47	0·663	Range $0^{\mu}{\cdot}200$.
" "	indigo	46	56	0·390	Range $0^{\mu}{\cdot}382$.
" "	red	43	21	0·772	Bunsen burner.

(Luminous flame $4^{\rm cm}$ high, at point one-third down from top, just within inner and slightly darker cone, seen through hole $2{\cdot}5^{\rm mm}$ in diameter.) Under these circumstances the spectrum of the insect's light was in the green a fair match for that of the burner, elsewhere the latter was brighter but not very greatly so. Since the insect's spectrum was followed through $0^{\mu}{\cdot}18$ with the thoracic light while with that of the same character but double the brightness it was followed only through a very little more, or $0^{\mu}{\cdot}20$, and while at the same time that of a but slightly brighter artificial flame was followed through nearly double or $0^{\mu}{\cdot}38$, it seems probable that the insect's light actually ceases near the given limits, and does not merely disappear from the inability of the eye to follow a diminishing light. While we observe from these first photometric measures that the insect's spectrum has undoubtedly a decided maximum in the green, we are led to infer that this spectrum is very probably of the nature of a broad band stretching from beyond F to near C *where it terminates*, and this very important inference we shall see confirmed later by other and more exact measures.

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* In the normal spectrum the maximum has a wave-length $0{\cdot}^{\mu}57$.

August 5. Comparison of relative brightness in different parts of spectrum of abdominal light with that from a student's lamp.

A spectrometer supplied with means* for bringing into the same field the spectra of two different lights, formed by a Rutherfurd grating of 17296 lines to the inch (instead of the prism) was employed for this purpose. The upper half of the slit received the insect's light, the lower half a beam from the brightest part of the Argand flame, which had passed through two Nicol's prisms, one of which was attached to a divided circle. The two spectra were then seen in the same field with their edges in exact juxtaposition. In the field of the observing telescope was a slit 1^{mm} wide, subtending not quite 9·5 (minutes of arc), which allowed light having a range of wave-length of about 0^{μ}·01 to pass. The spectrum of the lamp-light was brighter in every part of the field though in unequal degrees till it was diminished by turning the Nicol's prism. The angle through which the prism was turned to produce equality having been noted, the values deduced from the ordinary formula (transmitted light $=l \cos^2 \alpha$, the angle α being 90° when the light is diminished as much as possible by crossing the planes of the Nicols at right angles) are as follows, where the fractions are those by which the brightness of the lamp spectrum at the various points is to be multiplied to produce equality with the insect spectrum.

Part of spectrum corresponding to center of slit at focus of observing telescope.	Blue green very near F	Green near b	Green near E	Yellow green.	Citron.	Yellow.	Orange yellow near D	Orange.
	μ	μ	μ	μ	μ	μ	μ	μ
Wave-length,	0·49	0·51	0·53	0·54	0·56	0·58	0·59	0·60
Brightness,	0·02	0·21	0·34	0·37	0·24	0·19	0·17	0·09

Owing to the motion of the insect and the varying brilliancy of the light emitted, these figures (each of which is the result of the mean of several trials including at least two measures) still leave much to be desired. The supply of the insects which had been procured and maintained alive with difficulty, however, did not allow of the experiments being further prolonged, nor of the securing a direct comparison with the solar spectrum. The value of each part of the lamp spectrum having, however, been independently determined with all possible exactness in terms of the solar spectrum, we are enabled to exhibit a comparison of the latter with the insect spectrum so as to show them together (Plate IV, figs. A and B). It is assumed that the same amount of luminous intensity (i. e. energy in terms of vision as determined by purely photometric methods) is taken whether from the sun or the insect. The subjoined curves (Plate IV, fig. 1) show the solar and the insect luminosity throughout the visible spectrum on the preceding assumption of the intrinsic equality, a result which, however, might be liable to a slight correction of the relative places of the maxima if a direct comparison with sunlight were obtained. The important fact, however, seems to be brought out almost beyond question that when spectra are formed from two *equal* lights, one from the sun the other from the insect, the latter's spectrum terminates both at an upper and a lower limit at which the solar light is still conspicuous. The conclusion follows that the insect spectrum is lacking in the rays of red luminosity and presumably in the infra-red rays, usually of relatively great heat, or that it seems probable that we have here *light without heat*, other than that heat which the luminosity itself comprises and which is but another name for the same energy.

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* Alluded to but not fully described in this Journal, August, 1877.

Any other supposition would apparently involve the hypothesis that the spectrum, which we have seen end at the red, has a renewal in the invisible infra-red where the main portion of the solar heat and that of all ordinary illuminants is known to exist. Although this last hypothesis cannot be considered to have much weight, and though we are led to agree with previous observers that it may be assumed with much probability that the ordinary invisible heat would, if we had means to observe it, be found unassociated with the fire-fly's light, yet this assumption is itself far from being proof, and in view of the great importance of the conclusions in question, we shall now try whether it be possible to settle the point by thermal measures with the bolometer.

PART 2. THERMAL OBSERVATIONS.

To give an idea of the amount of heat at our disposition for experiment, and of the actual minuteness of the radiation which proceeds from even the most luminous tropical insect, we may say that if that rate of radiation from a lamp-black surface 1 sq. cm. in area, which represents the amount of heat necessary to raise 1 gram of water, 1° centigrade, in 1 minute (i. e. one small calorie) be taken as unity, then the luminous radiation of the fire-fly's heat, per square cm. of exposed uminous surface, as we have found, is about 0·0004 calorie in 10$^{\text{sec}}$, and the total luminous radiation from the most powerfully illuminating light spot of the insect (the abdominal one) will not exceed 0·00007 calorie in the same time. But a small portion of this could fall upon the bolometer, and that which actually reached it during the time (10$^{\text{sec}}$) required for each observation, was sufficient only to affect an ordinary mercurial thermometer having a bulb 1$^{\text{cm}}$ in diameter by rather less than 0°·0000023, or by less than $\frac{1}{400000}$ of one degree centigrade.

We have just mentioned that the total amount of heat radiation upon which we have to make our investigation represents less than $\frac{7}{100000}$ calorie, while that portion of this which falls upon the apparatus, would in the time of one operation, only raise the temperature of an ordinary mercurial thermometer by less than $\frac{1}{400000}$ degree, and we have first to notice the difficulty that in case invisible heat exists in company with the light (and it certainly does exist in ordinary emanations from the surface of any living creature independent of phosphorescence), we have in this minute radiation, heat of two different kinds, both invisible and which it is yet indispensable for us to discriminate.

We are helped to do this by the consideration that while the insect, like any non-luminous one, must emit "animal heat" from all its surface, its general surface temperature is certainly low, since it feels cold to the hand whose greater warmth excites it to shine. This heat then corresponds to a temperature much below 50° Cent., and such temperatures must, as we have shown in other memoirs, be accompanied by the emission of waves whose length relegates them to quite another spectral region to that in which the invisible heat associated with light mainly appears. We can then discriminate the rays of this invisible "animal" heat without the formation of a heat spectrum by their inability to pass through a glass which transmits with comparative freedom, radiant heat whose wave-length is less than 3^{μ}, the latter including the region where if there be invisible heat radiated with the light it must mainly lie.

The heat in the spectral region of the infra-red we are considering, we know in advance must be, if it bear any sort of relation to the light, almost immeasurably small, and in fact it defied at first all attempts to obtain not merely a quantitative measurement but even any certain experimental evidence of its existence. At last upon July 24, with the arrival of a new stock of over two dozen insects and with the aid of experience derived from previous failures, these heat measures were resumed. For the first described, the thoracic light is taken.

The insect was placed 125$^{\text{cm}}$ from the mirror of 25·4$^{\text{cm}}$ aperture and 73·4$^{\text{cm}}$ focus, so that its image was formed at 178$^{\text{cm}}$

and enlarged about 1·42 diameters, when a small portion of it filled an aperture equal to the bolometer employed, which was selected from the most sensitive of those used in previous researches in lunar heat and had an aperture of $19^{\text{sq mm}}$. By the preceding arrangement of the mirror an image of one of the thoracic bright spots, with enough of the surrounding body to represent an area of about $13^{\text{sq mm}}$, was enlarged to nearly the surface of the bolometer.

Employing all the precautions taught by a multiplied experience, we obtained by a series of exposures of the bolometer to the insect radiation a series of small but real galvanometer deflections which represent the excess of total heat radiations from the insect over those from a metal plate of a temperature of about 25° C. forming the background. These heat radiations come jointly from the luminous spot (area 3 to $4^{\text{sq mm}}$) and about $9^{\text{sq mm}}$ of the surrounding body. To determine their characters we interposed a sheet of glass* which cut off all the observed heat. The heat from the luminous spectrum and from a spectral region below it extending to about 3^{μ} (30,000 tenth meters) was known to be capable of passing through this glass. The evidence then is that there is no heat in the spectrum below this feeble radiation from the luminous thoracic region, sufficient to be capable of affecting the apparatus, though this was so sensitive as to promptly respond to the feeble body radiation from the somewhat larger section of the luminous and non-luminous surface.

Continuation on Abdominal Heat.

The insects's light then is unaccompanied (in the specimen subject to this experiment) by any measurable heat, but to make it still more evident that this is due to the absence of heat below the red (body heat not being in question) we now proceed to take an artificial flame, occupying the same area as the radiating luminous part of the insect, and to see whether heat is observed in it. If the flame be no brighter than the insect, and the heat be nevertheless observed in it when in the insect heat is lacking, it is obvious that in the latter case none is observed because (sensibly) none is emitted, and this conclusion is reached *a fortiori* when the flame light is less than that of the insect.

July 27. Through a circular aperture $2{\cdot}5^{\text{mm}}$ in diameter, there was passed alternately the total radiant heat, and that transmitted by glass from a nearly non-luminous Bunsen flame, whose luminosity was very much *fainter* than that from the insects. On this day there seemed to be an exceedingly minute

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* Described in the Memoir "On the Temperature of the Surface of the Moon," Mem. Nat. Acad. of Sciences, vol. iii, as "B."

tion averaging ¼ of one division of the galvanometer scale
the total radiation of an equal portion of the abdominal
spot of the insect, while from the flame there was a mean
tion of 177·5 divisions, showing that the total heat radia-
from an equal area of a less luminous flame was many
red times that from the luminous area of the insect.
ass being interposed, the heat due to this flame radiation
14·5 divisions, or about 8 per cent of the original radia-
showing that of the quality of Bunsen flame heat immedi-
in question (that above 3^{μ} transmissible by glass), there
still something like 60 times that of the combined body
uminous radiation of the insect in the far less luminous
. Subsequently by the use of a lens giving greater con-
ation, measurable indications of insect radiation above 3^{μ}
herefore distinct from any possible body heat, were ob-
l through glass, showing the flame radiation of this quality
an equal area of the same intrinsic brilliancy, i. e. *invisi-*
eat and of long wave-length, but shorter than 3^{μ} to be
400 times that of the insect.

ese experiments were repeated with different luminous
s and with different insects on succeeding days. In some
em especially luminous insect specimens were secured
n with favorable conditions of the galvanometer, gave
measurable deflections on the latter. By a similar use of
lass to that described, it appeared that flames whose in-
c brilliancy is nearly comparable to that of a point below
iddle of the candle flame, and whose total brilliancy is as
ly as possible comparable to that of the insect, give several
red times the heat of the latter, even if we consider only
quality of heat which is found above 3^{μ}, while if we com-
the total radiations (i. e. those directly observed without
se of the glass) the contrast is still stronger.

follows that the insect light is accompanied by approxi-
ly one four-hundredth part of the heat which is ordinarily
iated with the radiation of flames of the luminous quality
ose which were the subject of experiment. This value is
rmed by other methods which we do not give here. It
onduce to a clearer comprehension of this, if we exhibit
series of curves derived from our observations, the spec-
listribution of one unit of energy in the gas flame spec-
(Plate V, fig. 1); of the electric arc spectrum (Plate V,
); of the sun (Plate V, fig. 3); and of the insect (Plate
g. 4). In all these the abscissæ are the same, the portion
een 0^{μ}·4 and 0^{μ}·7 (violet to red) showing the part of the
y utilized in light, while that from 0^{μ}·7 to 3^{μ} shows the
wasted as invisible heat. The energy in each case being
ame, the areas are the same, except that owing to the

relative importance of the light heat curve (fig. 4) only about $\frac{1}{20}$ of the latter can be shown in the limits of the plate.

The curves in Plate IV deal with luminous intensity only and give no means of drawing those economic conclusions which appear to follow from our experiments, and which the curves in Plate V supply. These curves (Plate V) all exhibit the spectrum on the normal scale, from that easily visible, lying between $0^{\mu}\cdot4$ in the violet and $0^{\mu}\cdot7$ in the red, then to 3^{μ} near the limit of the glass transmission. In the case of the first three, representing spectra of the gas flame, the electric arc, and the sun, nearly all the energy lies above 3^{μ}; in that of the gas-flame a considerable portion lies below 3^{μ} (and still more in that of the candle-flame, if that were shown where most of the energy would lie below 3^{μ} or outside the limits of the drawing). The curves, then, we repeat, represent equal amounts of energy (which without sensible error we may assume to be all exhibited as *heat*) and inclose equal areas.

The total area represents in each case the expenditure of a unit of cost in thermal energy, the area between $0^{\mu}\cdot4$ and $0^{\mu}\cdot7$, the proportion of this utilized as *light*, though as we have just stated, in the case of fig. 4, the representative of the fire-fly spectrum, only a fraction of this can be shown (owing to the limits of the drawing.)

Resuming then what we have said, we repeat that nature produces this cheapest light at about one four-hundredth part of the cost of the energy which is expended in the candle-flame, and at but an insignificant fraction of the cost of the electric light or the most economic light which has yet been devised; and that finally there seems to be no reason why we are forbidden to hope that we may yet discover a method (since such a one certainly exists and is in use on the small scale) of obtaining an enormously greater result than we now do from our present ordinary means for producing light.

APPENDIX.

Determination in Calories of the Heat in the Luminous (Abdominal) Radiation of Pyrophorus noctilucus.

The determination is reached by two steps: (1) The calibration of the galvanometer, so as to give the value of its division in calories; and (2) the inference from the observed deflection in divisions of the total of calories radiated.

1. The bolometer, whose face occupied 0·19 sq. cm. (a), gave a deflection of 342 divisions (b), at a distance of 25 cm. (r) from a 5 cm. circular aperture filled by a blackened Leslie cube. Seen from the center of this aperture, the bolometer occupied, then $\frac{a}{2\pi r^2} = 0\cdot0000484$ of the hemisphere, and would have received this

fraction of the total radiation, except that being placed exactly opposite the radiating surface, more than the mean radiation fell on it in a proportion which calculation shows to be about ⅓. The fraction of the total radiation which it actually received, then was 0·0000645 (c).

Accordingly the total radiation would have caused a deflection $\frac{b}{c} = 5300000$ divisions.

The surface of the cube was at a temperature of 99° Cent. and was limited by the diaphragm to an area of 19·6 sq. cm. (d). The total radiation from one centimeter then would have caused a deflection of $\frac{b}{cd} = 270400$ div. The temperature of the bolometer, which was that of the apartment was 20° C. According to Dulong and Petit's law, the radiation from such a surface at 99° C. to one at 20° C. would be 1·11 cal. per minute (e), which does not greatly differ from our own independent determinations, and for $10^{\text{sec.}} = \overset{\text{min.}}{0{\cdot}167}$ (f), (the time of the galvanometer swing), it equals $\overset{\text{cal.}}{0{\cdot}185}$ (ef). Hence $\frac{b}{cdef} = \frac{270400}{0{\cdot}185} = 1462000$ div. is the potentiality of work in 1 calorie, to be expressed in the swing of the galvanometer needle, and 1 div. $= \overset{\text{cal.}}{0{\cdot}000000684}$.

2. The galvanometer received the fire-fly radiation through a lens which occupied 0·00655 of a hemisphere, and would have transmitted this fraction of the total heat, except for its position, which caused it to transmit ⅓ more than the average, which is 0·00873 (g). The measured radiation from this fractional part gave $\overset{\text{div.}}{0{\cdot}84}$ div. (h) and $\frac{h}{g} = 96{\cdot}2$ div. is the deflection which would be given by the total abdominal emission, or

$$96{\cdot}2 \times 0{\cdot}000000684 = \overset{\text{cal.}}{0{\cdot}0000658}.$$

Since the luminous surface has an area of about ⅙ sq. cm., this corresponds to a radiation of $\overset{\text{cal.}}{0{\cdot}00039}$ per sq. cm. of radiating surface in the time of the galvanometer-needle's swing, or to $\frac{0{\cdot}0004}{f} = \overset{\text{cal.}}{0{\cdot}0024}$ per sq. cm. per minute.

(Taking the water-equivalent of the bulb of an ordinary mercurial thermometer 1 cm. in diameter at $\overset{\text{gr.}}{0{\cdot}25}$ we find

$$\frac{0{\cdot}84 \times {\cdot}000000684}{0{\cdot}25} = 0^{\circ}{\cdot}0000023$$

showing that if such a thermometer were placed in the position occupied by the bolometer its rise during the time of the latter's exposure to the radiation of the insect would be between two and three one-millionths of a centigrade degree.)

ART. XIII.—*Contributions to Mineralogy*, No. 48; by F. A. GENTH.

1. *Tetradymite.*

SEVERAL years ago, tetradymite was found two miles south of Bradshaw City, Yavapai County, Arizona. It occurs in crystalline masses, implanted in imperfectly crystallized, slightly ferruginous quartz, associated with pyrite. A few imperfect bladed crystals are visible suggesting an orthorhombic form, combination of the prism and brachypinacoid, with cleavage highly perfect brachydiagonal. Mostly in bladed crystalline masses, the largest blade in my specimens over 30^mm^ long and 6^mm^ broad. Some of the crystals, partly altered into a brownish white, amorphous substance, probably montanite, with a nucleus of tetradymite. After subtracting 15·6 per cent of quartz and 1·8 per cent of ferric oxide, the analysis gave:

Sulphur	4·50
Tellurium	33·25
Bismuth	62·23
	99·98

This gives nearly: $Bi_2(S_{\frac{1}{3}}Fe_{\frac{2}{3}})_3$, analogous to bismuthinite.

If the observation of rhombic forms is confirmed, it will place tetradymite (with exception perhaps of that from Schubkau), in its proper place in the system, in the group with stibnite and bismuthinite. The quantity of the altered mineral was too small for a fuller examination.

2. *Pyrite.*

The occurrence of arsenate of cobalt with the octahedral crystals of pyrite at the French Creek, Chester Co., Pa., Iron Mines, suggested the examination of the latter which was made in my laboratory by Mr. Aron Hamburger. The most perfect and purest crystals, averaging about 2^mm^ in size, gave the following composition:

S	54·08
As	0·20
Cu	0·05
Ni	0·18
Co	1·75
Fe	44·24
	100·50

The cobalt arsenate which occurs as a very thin coating upon rite, calcite, byssolite, etc., has not the usual appearance of ythrite, it is generally in microscopic crystalline groups of an pure rose color. It is very rare and large masses, showing would not have given 0·1 grm. of pure material. In order ascertain what its molecular composition might be, all porns of the specimens containing it were scraped off and in the ulting material the cobaltous oxide and arsenic pentoxide re carefully determined. I obtained: 0·0366 grm. $Mg_2As_2O_7$ d 0·0430 grm. $CoSO_4$, equal to: 0·0272 grm. As_2O_5 and 208 grm. CoO. This gives the molecular ratios of As_2O_5: O=1·18 : 2·8 or 1 : 2·36 instead of 1 : 3, probably owing to e substitution of some other base, perhaps CaO or MgO for portion of the cobaltous oxide.

3. *Quartz, pseudomorphous after Stibnite.*

Mr. Wm. H. Schlemm, of Durango, Mexico, kindly sent me me fragments of a mineral from this locality for identificaon. There were about half a dozen pieces—most of them of yellowish white dull earthy mineral intermixed with crystalle quartz. One of the specimens showed a coating of stibnite th a beginning alteration. Others contain the stibnite, with e prismatic and brachypinacoid planes, completely altered to a yellowish white quartz. A qualitative analysis proved e presence of very small quantities of antimonous oxide.

4. *Gold in Turquois from Los Cerillos, New Mexico.**

In many collections, specimens of gold enclosed in or assoted with a bluish green mineral are represented as turquois th gold from the celebrated locality Los Cerillos, New exico. Through the kindness of Messrs. Geo. W. Fiss and mes W. Beath of this city, I received specimens for examition. They proved that neither contained any turquois. th are said to come from Arizona.

a. The specimens from Mr. Fiss consisted of a compact, ghtly greenish sky-blue mineral. H.=2; sp. gr.=2·487. ith finely granular grayish white quartz and finely cryslline, deep yellow gold, coating the bluish mineral and o disseminated through the quartz. The analysis of the blue ineral is given below (*a*), and, for comparison the analysis of variety of turquois from Los Cerillos, almost identical in pearance with the former (*b*.)

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* At my request, the distinguished archæologist Dr. Ad. F. Bandelier, under e, Santa Fe, New Mexico, April 15th, 1890, informs me that *he never had seen y gold, associated with turquois, from Los Cerillos, and that he had never heard of yone who had found gold together with turquois.*

	a.	b.
Loss by ignition	14·30	19·93
SiO_2	46·19	1·42
Al_2O_3	38·82	40·81
Cr_2O_3	0·82	....
Fe_2O_3	....	2·19
Cu	....	8·83
P_2O_5	....	26·52
	100·13	99·70

From this analysis it will be evident that the gold-bea mineral is not turquois, but a *chromiferous clay*.

b. Entirely different is the auriferous mineral received f Mr. James W. Beath. It consists of brown ferruginous qu apparently free from gold with a vein from 5 to 12^{mm} in w of a greenish blue quartz with crystalline, deep yellow disseminated. The analysis of the greenish blue mineral g

Loss by ignition	4·44
SiO_2	86·75
CuO	8·60
	99·79

or a quartz with an admixture of about 19 per cent of chr colla.

5. *Zircon.*

With the masses of monazite at Mars Hill, Madison N. C., is rarely associated zircon in crystals of consider size. One, which I picked out from a lot of monazite, nished the material for the following analysis. It was 4 long, 23^{mm} broad, rough and irregular, showed only the p and several pyramidal planes. Spec. gr.=4·507. The anal gave:

Loss by ignition	1·20
SiO_2	31·83
ZrO_2	63·42
Fe_2O_3	3·23
	99·68

6. *Scapolite.*

At the Elizabeth Mine, French Creek, Chester Co., Pa., depth of 400 feet small crystals of scapolite have been served, as a rarity;—it appears to have resulted simultaneo with another variety of garnet from the alteration of essor They are filling cavities of a brownish gray and ash-net, associated with magnetite, pyrite and remnants of the nite. The crystals are columnar, the best are the smallest show combinations of the 1st and 2d prism with the basal acoid; no pyramidal planes could be observed. The larger stals are deeply striated, by which all planes are obliterated. ir size varies from 2^{mm} in length and $0·25^{mm}$ in thickness to ^{m} in length and 5^{mm} in thickness; frequently in groups. orless to white and grayish white. Spec. grav.=2·675. analyses gave:

	a	*b*
Loss by ignition	1·50	1·51
CO_2	2·63	not det'd
SiO_2	52·30	52·26
Al_2O_3	23·68	24·15
Fe_2O_3	0·58	0·43
MgO	0·05	0·16
CaO	12·36	11·76
Na_2O	6·29	not det'd
K_2O	0·77	" "
	100·06	

7. *Garnet.*

This garnet which results from the alteration of essonite ws occasionally dodecahedral and trapezohedral planes which sometimes coated with a thin shell (not over $0·5^{mm}$ in thick- s) of the original mineral of a bright cinnamon-brown or. The purest has a brownish gray or ash-gray color and a c. gr. of 3·390. The analysis gave:

	a	*b*
Loss by ignition	0·51	not det'd
CO_2	1·71	
SiO_2	41·42	41·69
Al_2O_3	18·09	18·37
Fe_2O_3	10·81	10·27
MnO	0·88	0·93
MgO	0·59	0·52
CaO	26·19	26·10
	100·20	

8. *Titaniferous Garnet.*

The late Thos. S. Ash brought from the Jones Mine on en River, Henderson Co., N. C., a variety of garnet which ave analyzed.

t is massive, of a splintery uneven fracture, has only slight ications of dodecahedral planes, brown color, spec. grav. ·738. The analysis gave:

Loss by ignition	0·55
SiO_2	35·56
TiO_2	4·58
Al_2O_3	4·43
Fe_2O_3	20·51
FeO	1·88
MgO	0·17
CaO	31·90
	99·58

9. *Allanite.*

In the hope to find among the minerals which were associated with the corundum and the pseudomorphs of spinel (pleonaste) after corundum, which I described in 1873 in the Proc. Am. Philos. Soc., xiii, pp. 361–406 the rare tscheffkinite, I examined two varieties which I had in my collection as allanite?

a. The first variety has a velvet-black color, shows a slight transparency with a greenish-black color and a vitreous luster. Sp. gr. = 3·546.

It is a pebble coated with white silica, resulting from partial alteration. The analyzed portion was of perfectly pure material (*a*).

b. The second variety is of a deep brownish black color, thin splinters with brownish black transparency, vitreous luster. Sp. gr. = 3·491. Two small pebbles, the surface slightly oxidized into a brown earthy coating. The material for the analysis was quite fresh and apparently pure (*b*).

	a	*b*
Loss by ignition	2·25	2·63
SiO_2	31·67	32·04
ThO_2	0·33	----
TiO_2	----	0·12
CeO_2	23·98	12·91
$(LaDi)_2O_3$		10·24
Y_2O_3	0·36	0·33
Al_2O_3	12·20	14·02
Fe_2O_3	4·42	7·17
FeO	10·89	7·52
MnO	2·52	0·37
MgO	2·08	1·47
CaO	9·37	11·34
	100·07	100·16

10. *Lettsomite from Arizona and Utah.*

Messrs. Geo. L. English & Co. brought this rare mineral from two new localities, but only one specimen has been obed at each, the Copper Mountain Mine near Morenci, ham County, Arizona, and at Copperopolis, formerly the erican Eagle Mine, Tintic District, Utah. They very lly placed all their material at my disposal which enabled to make a fuller investigation and clear away the doubts ting as to the constitution of this mineral.

The Arizona mineral forms narrow seams in a siliceous gue, coated with earthy varieties of limonite. The lettso- occurs in incrustations up to a thickness of about 2^{mm}. mall cavities it shows thin fibers and small tufts often with diated structure. Its color is from a deep sky-blue to e-blue; luster silky. Sp. grav. taken in alcohol 2·737.

ome of the lettsomite has undergone an alteration, begin- with a change into greenish yellow, and finally, by the loss he cupric oxide, into a fibrous yellowish white mineral. portions where the alteration has taken place the matrix is uently coated with a cryptocrystalline, mammillary hydrous inum sulphate. Neither could be obtained in a quantity cient for a fuller investigation.

he analyses were made with almost pure azure-blue tufts nd nearly pure sky-blue radiating particles (*b* and *c*).

	a	*b*	*c*	Mean.	Mol. Ratio.		
uble	0·46	0·38	0·48	0·44			
	not det'd	34·47	21·89	21·89	1·216	7·8	8
	12·38		12·59	12·49	0·156	1	1
	47·40	46·34	46·39	46·71	0·590	3·8	4
	15·71	16·94	16·77	16·47	0·161	1·0	1
	0·80	1·61	1·64	1·34	0·088		
		99·74	99·76	99·34			

onsidering the slight loss of cupric oxide by beginning ation, the ratio for $SO_3 : CuO : Al_2O_3 : H_2O$ is 1 : 4 : 1 : 8= $Al_2(OH)_{12} . SO_4+2H_2O$, which gives the following percent-composition:

Al_2O_3	102	15·88
SO_3	80	12·56
4CuO	316	49·23
$8H_2O$	144	22·43
	642	100·00

The lettsomite from the American Eagle Mine occurs n a bluish green mineral, which appears to be amorphous, -like, and evidently a mixture of clay and lettsomite. The lettsomite forms a velvet-like coating of azure-blue silky rs. The specimen being very small, only 0·055 grms. ld be obtained for analysis, which gave:

SO_3	12·60
CaO	49·54
Al_2O_3	15·45
Fe_2O_3	0·91
H_2O(by diff.)	21·40
	100·00

closely agreeing with the above composition.

Chemical Laboratory, No. 111 S. 10th St., Philadelphia, April 6th, 1890.

Art. XIV.—*A Curious Occurrence of Vivianite;* by Wm. L. Dudley.

While making the preliminary survey of the Cumberland river from Nashville to its mouth for the purpose of locating the locks and dams which are to be constructed by the Government, Assistant Engineer C. A. Locke discovered some "blue roots" embedded in a stratum of clay which had been exposed in the bank made by the erosion of the waters in cutting out the channel of the river. The locality was about two miles above Eddyville, Ky. The stage of the river was about six feet above low water mark, and the stratum containing the roots was about two feet above the surface of the water or eight feet above low water. The stratum is exposed therefore only for a limited season each year.

Maj. Locke gives the general characters and thicknesses of the strata exposed in the cut, as follows: Soil, 2 feet; light yellow clay, 15 feet; light drab clay, 15 feet, at the bottom of which the blue roots were found; below this an unknown depth of gravel.

The "blue roots" were found in such position as to indicate that they were in the place of their growth. The clay is described as having a blue color when wet, and I regret that a specimen of it was not collected for examination.

Four of these "roots," more or less perfectly preserved, were handed to me. They were from one-half to two centimeters thick and six to twelve long. The blue mineral which has almost wholly replaced the woody fiber of the roots is of a deep blue color resembling cobalt-blue but somewhat darker, and of a duller hue. It is earthy and very friable. There is no evidence of structure, and the specimens seem to be casts of the original roots, formed gradually as decay proceeded.

Some of the remaining particles of the wood were given a microscopic examination by Professor Jas. M. Safford, who pronounced it coniferous.

ɔr analysis some of the mineral was pulverized and susled in water. The small particles of woody substance ing were removed. Heavy brownish mineral matter in .l quantity rapidly settled to the bottom, and the water aining the blue substance in suspension was carefully ·ed off and allowed to settle during twelve hours. This ·ation was repeated and the mineral was in a very fair state urity. It was then dried in the air at the temperature of laboratory, and finally for twelve hours over sulphuric . Analysis gave the following result:

Water given off at 100°C	10·59	per cent.
" " " 230°	7·24	"
Alumina	17·74	"
Ferric oxide	9·35	"
Ferrous oxide	24·58	"
Lime	0·59	"
Magnesia	0·43	"
Phosphoric anhydride (P_2O_5)	27·71	"
Insoluble matter	1·84	"
	100·07	

'hen the water was driven off at 100°, the residue had a green color resembling chromic oxide. After heating to ' until all of the water was eliminated the color was light vn. In a desiccator, over sulphuric acid, the mineral lually lost water and for several days became green. This ırred more rapidly of course if the air in the desiccator was ıusted.

: in the above analysis, the lime, magnesia and insoluble ter be eliminated and the percentages of the remainder ɔalculated to 100, it is found that the mineral may be ' nearly represented by the formula $2(3FeO+P_2O_5)+Fe_2O_3$, $,O_3$, $(P_2O_5)_2+17H_2O$, or $2Fe_3P_2O_8+Al_2Fe_2P_4O_{22}+17H_2O$. ; seems to indicate that the ferrous iron in the mineral is bined with the P_2O_5 to form vivianite, $Fe_3P_2O_8+8H_2O$, Professor F. W. Clarke arrived at the same conclusion ı examining some specimens which I sent to the National ıeum.

: the double molecule of vivianite, $2(Fe_3P_2O_8+8H_2O)$, be subted from the above formula, there remains $Al_2Fe_2P_4O_{22}+H_2O$, ɔh resembles an almost dehydrated double molecule of tur-s, $Al_4P_4O_{22}+10H_2O$, in which one molecule of Fe_2O_3 has aced one of Al_2O_3. The mineral was so earthy and friable sections could not be cut, and therefore microscopic evi-ɔe is impossible.

emical Laboratory of Vanderbilt University, Nashville, Tenn.,
March 21, 1890.

ART. XV.—*Classification of the Glacial Sediments of Maine;* by GEORGE H. STONE.

THIS paper assumes the now quite generally accepted theory of Torell and Holst as to sub- and infra-glacial matter, i.e., that the till of New England consists in part of a ground moraine and partly of matter that was distributed through the lower portion of the ice-sheet.

Preliminary.—It is evident that every glacier is to a considerable extent bathed in its own waters and is drained by a system of glacial streams. The escaping waters continually carry away their load of detritus. The largest ice-sheet must have its system of drainage as inevitably as an ordinary Alpine glacier that is confined to a single drainage basin. The hypothesis that a given region was covered with land ice must carry the burden of proving that there was, over the region in question, a system of glacial drainage. The presence of such a system furnishes a crucial test between the theories of land ice, and icebergs or other forms of floating ice.

Reasoning from the analogies of the Alpine glaciers compared with what is known of the Greenland ice-sheet, I infer that near the front or lower extremity of every glacier (margin of a body of confluent glaciers or ice-sheet), there is a belt where the ice is so shattered by crevasses that the melting waters almost immediately escape to the ground. This part of the glacier is almost wholly drained by sub-glacial streams. Back of this zone is another where the drainage is chiefly effected by means of streams which flow in well defined channels on the surface of the ice, but at the last reach a crevasse down which they fall and escape by sub-glacial tunnels. Still farther back is a region which answers to the snow fields of central Greenland. Here the melting waters of summer are diffused through the unconsolidated snow of the preceding winter and slowly seep through the soft slush, but have not a motion sufficiently rapid to cause them to gather into streams and erode well-defined channels. The three regions just described pass one into the other by degrees. The breadth of these respective belts I infer to be determined chiefly by the rate of change in temperature as we go from the end of the glacier backward. The slower the rate of change in temperature the broader will be these belts. The gentle slopes over a large part of New England would tend to a slow rate of change in temperature, while the fact that these slopes were southward would cause a more rapid change, since it would introduce the effect of latitude on temperature. On the whole I estimate that these zones were pretty broad in New England, say from 75 to 100 miles for each of the two outer zones, while northern Maine was occupied by a snow field or only partially consolidated ice. During the final melting of the ice these zones of sub-glacial and superficial streams would naturally advance northward, and in course of time would cover most or all of the névé area.*

In classifying the glacial deposits a fundamental question is this: What is the difference between the till and the glacial sediments?

1. The test of stratification. One test proposed is that amorphous or pell-mell drift is till while the stratified drift is water drift, i. e., the sediments of glacial waters. This test is a true one as a rule but not always. Thus there is a quasi stratification of the clayey till of the lenticular hills, and on the other hand masses of gravel, of which the stones are well rounded and polished by water, have often by sliding lost their stratification so that now they show no sign of intermittent sedimentation.

2. The test of composition. Unwashed moraine stuff of an ice-sheet, whether sub- or infra-glacial, should contain fragments of all sizes permissible by the nature of the rocks. Practically it is not safe to affirm of any till that it is absolutely unwashed, though a till composed chiefly of clay cannot have lost any large proportion of its finest matter. No observer can fail to notice that the terminal moraines of either the great ice-sheet or those of the local White Mountain glaciers contain much less of fine detritus than the till of central and northern Maine. Evidently there was very little moraine-stuff near the extremity of the ice sheet which was not more or less water-washed. The moraines of the local Androscoggin glacier contain much less fine material than the till of the

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* The above stated hypotheses are consistent with the opinion of Mr. R. Chalmers of the Geological Survey of Canada that from the highlands south of the St. Lawrence River in Quebec the ice flowed north and eastward. This hypothesis would make the valley of the St. John River in Maine the area of accumulation from whence glaciers radiated north, east and south. In a paper on Glacial Erosion in Maine (published in the Proceedings of the Portland Society of Natural History in 1882), I dwelt at some length on the fact that the glaciation of Maine is less intense in the northern part of the State. This indicates névé-like conditions prevailing over northern Maine for a large part of the glacial period. This conclusion would be consistent with the hypothesis that the radiating flow discovered by Mr. Chalmers continued throughout the whole of the glacial age, or with the hypothesis that it was only a feature of the last days of the ice-sheet. For even if we suppose with Prof. Dana that the highlands near Hudson's Bay were the radiating area during the time of maximum glaciation, it is as yet permissible to suppose that in late glacial time the rising Champlain sea melted its way up the valley of the St. Lawrence, thus isolating the portion of the ice-sheet lying south of that valley. If so, the ice would for a time flow northward from the water-shed of the St. John and from the Notre Dame hills. In other words, late in the ice age northern Maine and the adjacent territory would for a time be the area of accumulation from whence the ice-flow radiated, no matter what may have been the earlier history of the region.

adjacent country. The fact, then, that the finest matter has been washed out of a mass of glacial-drift does not necessarily prove that it is not true moraine-stuff. In Maine, the till being largely derived from slates, limestones and feldspathic rocks naturally contains a large proportion of clay. A sandy till is here almost always a water-washed till, and it is generally easy, by a comparison of a suspected deposit with the till of the neighborhood, to determine whether the deposit has been modified by water or not. Such a comparison would not be so easy over a large area of quartz sandstone. It is therefore difficult to always apply the test of composition to distinguish till from glacial sediments.

3. The test of transportation. According to this test, all matter brought to its final position by ice movements would be termed till, while that which was brought to its final position by the water of glaciers would receive the name glacial sediments. This test at once distinguishes from the till all the sedimentary clays containing drift boulders and sometimes fossils which have been named boulder clays, and which have often been confounded with the true morainal till,—to the great detriment of glacial science.

The first and second of the above mentioned tests leave the kames and osars in the same class with terminal moraines. On the whole, the test of transportation is the best single test whereby to distinguish the till from the glacial sediments. Besides the three tests named, there are several others which are often of great importance. In the field the method of transportation of a given mass of drift has to be determined by its structure, its composition, the shape of the individual drift fragments and their markings, the shape of the mass, etc.

The sediments transported by the waters of the ice-sheet were deposited in various situations.

1. In channels bordered on both sides by ice, partly in subglacial tunnels, partly in channels open on the top to the air. Such channels varied in breadth from a few feet up to a mile or more. They were often locally enlarged so as to form pools or lakes. Sediments dropped in them now form two-sided ridges or plains.

2. In channels bordered on one side by ice, on the other by the land. The sediments left in such a channel now form a terrace along a hill-side.

3. In channels bordered for most of their length by ice, but in some parts of their courses extending across a whole valley. The rivers that flowed in such channels were so far confined by ice walls that we must term them glacial rivers, yet for a few miles in the midst of their courses, they were bordered by land on both sides like ordinary rivers.

front of the ice, (*a*) in the sea, (*b*) in lakes on the
med where the land sloped toward the ice, (*c*) on a
face sloping away from the ice.
ents deposited in all these situations are to be found
.*
ames below given to the different kinds of glacial sed-
re provisional. The deposits are classified according
size, their shape, and their structure, their relations to
rms of glacial sediments, the conditions of their de-
etc. Two-sided ridges not longer than about two
termed kames, longer ridges are termed osars. Erosion
. e., portions of a plain of sediment which have been
idges in consequence of the erosion of the adjacent
the plain, are never by me termed either kames or
he latter terms are here applied *only* to sediments
y deposited as ridges.†

CLASSIFICATION.

lated kames.—These are found in all parts of Maine,
the extreme north, which region I have not explored.
outh-western part of the drainage basin of the Saint
ey are the only form of glacial sediment yet found by
eported by others. They are so distant from other
ediments that they are termed isolated, thereby mean-
so far as known they are the only sediment deposited
lacial stream which formed them. They may consist
gle ridge or of a plexus of ridges enclosing kettle-
They plainly consist of residual matter, i. e., of till
ts from which the finer detritus has been removed by
water. The stones are more or less water-worn, often
ch rounded. What has become of the finer matter of
? It has disappeared from the place of the kame,
nds in sand or gravel, and there is no auxiliary clay
show where the finer matter that was carried away by
ial stream has been deposited. When kames proper
d above the contour of about 230 feet, they usually
he north, east and west in areas of unmodified till, and
es also on the south. When not surrounded by a till-
country, they are found in the midst of the alluvium
s, but there is no traceable connection between the
ns of sediment. The valley drift in these cases is a
osit than the kame.

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ermits only the presentation of a portion of the outlines of the sub-
details have been embodied in a report written for the U. S. Geolog-
, completed June, 1888.
re assumed to be not a matter of much importance whether we form
after the Swedish forms Ose—Osar, or regard the words to be thor-
licized and term them Osar—Osars.

These kames are heaps or ridges of sand, gravel and coarser matter piled above the surrounding level, usually in places where no ordinary surface stream can have deposited them. They are just such deposits as would be formed in channels between ice walls by waters which retained sufficient velocity to carry off the clay and finer sand. The hypothesis of land ice fully accounts for the confinement of streams by barriers which now have disappeared. No other adequate physical agent than land ice has been suggested.

I have thus far not been able to find ravines of erosion in the till to the north of these kames, hence there is no direct evidence that a sub-glacial stream flowed from the north to form the ridge. A better interpretation is that the gravel was deposited in the enlarged sub-glacial channel or pool that formed at the foot of the cascade where a superficial stream fell down a crevasse. They can also be accounted for as having been deposited in deep pools in the bed of a superficial stream. It is not necessary to assume that all the kames were formed in the same manner.

The isolated kames vary in size, and many of them are only a few feet wide and high. They appear to have been deposited by small glacial streams that drained only a limited area. In most cases they were probably formed during the last days of the ice.

2. *The hill-side kames.*—An interesting class of isolated kames. They are found on the south slopes of rather high hills and at the bottom of the hills they often expand into a plexus of reticulated ridges, and sometimes into a small delta-plain. In this plain we find a gradual transition from coarser to finer sediment as we go southward. This proves that the glacial stream flowed into a body of still water and lost its motion. Such a deposit is in this paper named a delta. Sometimes this delta seems to pass by degrees into the valley drift, which proves that the glacial stream flowed out from the front of the ice into a valley over which the ice had already melted. Such is by me termed a frontal delta, or plain, being formed in front of the ice.

The hill-side kames are found above the contour 230 feet, in the hilly country lying from 50 to 125 miles from the coast. They are quite common in the region specified, especially in the hill country of western Maine, situated south of the Androscoggin river. They vary in length from a few feet up to a mile or two. In several cases ravines of erosion are found in the till to the north of the kames. Even these small kame-streams eroded the till to a depth or twenty or thirty feet and to a breadth of 100 or even 200 feet. The eroded matter was swept down the hill and helped form a plexus of reticulated ridges or a delta near the base of the hill. In some cases ɜ the hill-side kames are large, a deep sheet of till lies to ıorth of the ridges, and there is not a sign of an erosion e. We thus see that the details of the formation of these s vary greatly. The slopes of the hills on which they ituated are pretty steep—usually 100 feet or more per None of this kind of kames have been found on north s.

Maine almost every winter there are small ridges of earth ed on hillsides within the channels in the snow and ice, ıced by the melting water cutting down through the snow ;he soil. These small ridges are in several respects types ıe hill-side kames. The latter are found in places where rdinary stream can have existed, even in time of the est floods. The glacial origin of the hill-side kames is made certain. Most of them were probably deposited in ;lacial channels in very late glacial time.

Kames ending in marine deltas.—A good example is d in Amherst. Two short hillside kames converge ;her at the base of the hill and expand into a plain of ɜl which becomes finer and more nearly horizontally strat- as we go south and southeast. Within about one-fourth mile the gravel passes into sand and this into clay. This is continuous with clay containing marine fossils within a or two of the plain. The horizontal transition of gravel sand and finally into the marine clay leads to the infer- that the glacial streams here poured into the sea and as vaters were slowly checked they dropped their burden of ɑent classified horizontally according to the relative veloc- of the currents. There are many other small marine deltas ıe State connected at their northern ends with either e kame ridges or with a plexus of reticulated ridges. structure of the marine deltas will be referred to again.*

ıe hypothesis that the reticulated kames were deposited in the sea was first hed by Prof. N. S. Shaler in 1885. That the great sand and gravel plains :k and Cumberland Counties were in large part composed of matter depos- ıy glacial rivers in the sea was determined by the writer independently ; June, July and August, 1885, while in the employ of the U. S. Geological y, and the conclusion was set forth in administrative reports of that time. ridges of gravel are formed at the sides of swift streams entering stiller was discovered by me at the dam of the Penobscot river, at the foot of the Twin Lake in 1879, and was at once utilized in explanation of certain extending back from the alluvial plain of the Androscoggin River, in a ɔn the Androscoggin glacier in the American Naturalist. But I did not liscover the application of the principle to the case of the marine deltas of l sediment. I have since discovered a fine example of gravel ridges enclos- kettle-hole below the dam of the Mattawamkeag River, at Kingman. No ho examines these reticulated ridges below the Kingman dam can have a that the swift sediment-laden glacial rivers entering the sea or a lake, or ı pool-like enlargement of a river channel, could form ridges enclosing ket- les. In this case the kettle-holes represent unfilled space around which the were deposited. In other words it is not necessary in the case of the ı of reticulated ridges that formed at the land-ward or ice-ward ends of the

4. *Kames ending in lacustrine deltas.*—In hundreds of places along the coast of Maine the writer has traced the beaches of the sea up to a certain level and there lost them altogether. The highest beach that I can find is at an elevation of 225 to 230 feet in the Kennebec region and 220 to 225 in eastern Maine. Beaches can be found at these elevations on every hill that would be a projecting headland when the sea stood at this level. Only a limited amount of erosion was performed by the sea while it stood above its present level. No terraces of erosion were made in the solid rock that I have been able to recognize. On the most exposed headlands the till was eroded and the glacial striæ effaced from the bared rock, but the *roches moutonneés* remain. A few miles northeast of Machias on the south slope of a high hill a deep sheet of till shows a cliff of erosion and a beach at about 225 feet. The cliff is now much fallen, but estimating from the size of the beach-terrace it could only have been from six to ten feet high and the erosion did not in some places reach to the bottom of the till. This occurred on a slope which would be exposed to the full force of the Atlantic at that time. Above this beach the hill rises two or three hundred feet and shows nothing but ordinary unmodified till. For these and many other reasons I assign the highest elevation of the sea on the coast of Maine that occurred in late glacial or in post-glacial time at about 230 feet above the present sea level. During earlier glacial time the sea may for a time have stood at a higher elevation

The deltas deposited in glacial lakes are situated above the contour of 230 feet, and most of them are on the north sides of hills where during the melting of the ice a lake would be confined between the ice on the north and the hills lying to the south. These deltas present the same horizontal sorting of sediments as the marine deltas, except that they do not pass by degrees into fossiliferous marine clay like those found below 230 feet.

5. *Massive kame-plains.*—These are somewhat rounded or sometimes rather level on their tops. They contain no kettle-holes proper though the surface may be rolling or uneven. They show only an imperfect and irregular assortment of sediments from coarse on one side to fine on the other. They end

marine deltas, to postulate masses of ice that occupied the places now represented by kettle-holes.

In my paper on the kames of Maine, read before the Boston Society of Natural History in 1880 I recognized that the plains here termed marine deltas of glacial sediment were marine deposits, but I supposed they were composed of kames re-classified by the sea. This was based on an exaggerated estimate of the erosive action of the sea. As soon as I had proved that the sea waves of the epoch wrought but a very limited amount of erosion it became evident that the plains in question had been deposited in their present state in the sea.

ɔtly in gravel or sand, and the marine clay which usually ies them is plainly a later deposit, not contemporaneous. are mostly found below 230 feet. They vary much in ɑp to half a mile in breadth and two or three miles in h. The coarseness of the sediment proves that the waters ɩe glacial rivers were never so far stopped as to permit to drop the finer detritus, as would have happened if a ɪl stream poured into an open body of water of the size of ɾhole plain. The best interpretation of the facts is that a ɪl stream poured into a pool or lake within the ice. This was not large enough to stop the stream sufficiently to ꞉ it to deposit its clay but did check the current somewhat to make it drop the coarser sediment. Thus it happened the central part of the pool was filled with sand and ɪl while at the same time the pool enlarged by melting erosion of the adjacent ice. Thus after a time the real consisted of a narrow strip of water situated between the al bar of gravel and the surrounding ice. In this narrow ge the velocity of the water was not sufficiently lost to it the deposition of the finer sand and the clay, nor were arge kettle-holes made. The stratification of such portions ɩese broad plains as I have been able to examine is irregu- quaquaversal.

the northeastern part of Monmouth are three deposits consisting of two elongated-semicircular plains of coarse ɑent separated by a central ravine. The plains are situ- on hills where no stream can have existed to account for ·avines by ordinary stream erosion. My interpretation is a swift glacial river flowed into one side of a lake con- d within ice walls and out at the other side without losing ı of its velocity. The ravines mark the channel of the ɪl river, while the lateral gravel plains collected in the water on each side of the swift current. These plains are ourth of a mile in diameter, one of them somewhat more. e thus find several transition forms between the kame ɜr and the complete delta, i. e., the plain that was formed body of water sufficiently large, as compared with the size e glacial river, to completely check the flow of the incom- vater. Some of these intermediate forms perhaps deserve ꞔnition in our classification.

The discontinuous kame systems. — These consist of sits of glacial sediments, arranged in linear series, and sep- ꞉d by intervals varying in length from a few feet up to or three miles. When mapped, the linear arrangement is obvious. The gravel takes the form of domes, cones and t ridges, often of considerable breadth so as to be plain- These massive ridges or plains are found here and there in the midst of the series, and most of the systems contain in their courses one or more marine deltas. When there are more than one delta they are separated by intervals of several miles.

It should be carefully noted that these gravel deposits are separated by reaches of undisturbed till and marine clay. This proves that these deposits were not once continuous and they have not become discontinuous by recent erosion of the intervening parts. In short, for some reason a glacial stream here deposited its sediments at intervals, not continuously.

Systematic non-continuity is a feature of the glacial gravels of the coast region of Maine, and is found in only three cases above 230 feet.

All of the longer gravel systems, including the great osars and osar-plains, become discontinuous as we approach the ocean.

The general law is that as we go south from the contour of 230 feet the glacial gravels become more and more discontinuous, i. e., the intervals become longer, the gravel deposits become shorter and smaller. Almost all the systems end north of the present shore, and but a few feet above sea-level. In Belfast and Penobscot bays several gravel systems enter the sea, but these bays extend considerably north of the general line of the coast. The above remarks apply only to the country east of Portland. I have only partially explored the coast south of Cape Elizabeth.

The elongated cone and the dome are the prevailing shapes of the smaller masses of glacial gravel in the coast region. So characteristic is the shape that they may well be termed lenticular kames. Their stratification is often somewhat quaquaversal.

Since for many reasons (more fully set forth in my report), a line of these separated kames is considered as having been formed by a single glacial river, they are classified as a single system, hence a discontinuous system.

The cause of systematic non-continuous sedimentation furnishes one of the most obscure problems connected with the glacial sediments. The subject is discussed at length in my report.

The maximum development of glacial sediments is found near the contour of 230 feet, and the amount diminishes in opposite directions from this line. This fact leads to several interesting inferences, but lack of space prevents further discussion of the subject at present. I will close by remarking that it will yet be possible by a study of the terminal moraines, the glacial marine deltas, etc., to map pretty accurately the general outline of the ice-front as the ice retreated northward before the sea.

7. *The Osars.*—These are the longer two-sided ridges. Several of them are more than 100 miles in length. Near the north

ds of the longer systems, the ridges have an uneven surface
d steep lateral slopes like some moraines. The material is
rely water-worn. It is till with the finest detritus washed
t of it, and the stones have been left, but little changed from
ir till shapes. As we go southward the stones become very
ich worn and rounded. The facts are only to be accounted
as due to glacial rivers flowing southward in narrow chan-
ls bordered by ice walls. Rising out of the rather level
gions of central and eastern Maine to a height of 20 to 150
t above the adjacent land, these long embankments form a
narkable geological construction. They freely pass over
ls of moderate height from one drainage basin to another
d they cross rivers and lakes. The ridges are seldom con-
uous for more than ten miles, because they are usually in-
rupted near the tops of hills crossed by the systems, also on
wn or southward slopes of thirty or more feet per mile.
re there appear to be topographical causes for such swift
rrents as would sweep the ice-channels clear of sediment.
the contour of 230 feet or not far south of it, they become
gularly non-continuous, even when traversing quite level
ins where there is no apparent topographical reason for the
erruption. At first the unconnected ridges are a mile or
o long and the gaps between them are short. By degrees
system passes into a series of lenticular kames separated
intervals many times as long as the kames themselves (up
a mile or more). This gradual passage of a nearly continu-
s ridge into a series of far-separated heaps furnishes part of
argument for regarding a non-continuous kame system, so-
led, as having been deposited by a single glacial river, but a
rt one. If it had extended north farther into the interior,
ontinuous ridge would probably have been formed in the
rthern portion of its channel.

Most of the osars expand into one or more marine deltas.
hen there are more than one, they are situated ten to
enty-five miles apart, and the largest one is in most cases,
one farthest north and nearest the contour of 230 feet.
me of them contain ten or even twenty square miles.

Marine deltas of glacial sediments are of at least two well
fined classes.

1. *Fan-shaped Deltas.*—In this class, as we pass from the
a where the reticulated ridges are highest and enclose the
pest kettle-holes, we find the coarser sediments becoming
er in all directions both in front and laterally. Here evi-
tly one or more glacial rivers flowed into the open sea,
ere they were free to spread outward through a semicircle.
ing outward we find the gravels becoming sands and the
ds become finer and at last pass into the marine clays.

At the same time the lateral slopes of the reticulated ridges become less steep, the kettle-holes shallower, the ridges broader, and thus the plexus of ridges is merged in a rolling plain which becomes more and more even until it is a level plain of nearly horizontally stratified sand and at last clay. The position of the mouth of the glacial river is shown by the kame or osar extending north from the delta.

2. *Narrow Marine Deltas.*—In shape this kind of delta is a long plain a half mile or less in breadth, and expanding but little in breadth toward the south. There is a gradual transition from coarser to finer matter as we go southward and at last the sand ends on the south in the marine clay. But at the sides the northern portion of this plain usually rises abruptly several feet above the adjacent ground. The marine clay here overlies the sand or gravel plain which consists of matter much coarser in composition than itself, proving that the clay is a later deposit than the gravel and sand plain. My interpretation of the facts is that these deltas were formed in wide channels forming bays by which the sea extended some miles back into the ice-sheet. At the time of deposition the delta was bordered by ice on each side, while the open sea lay in front. As the channel or bay broadened by the melting of the ice, the parts adjacent became covered by clay, derived from the glacial stream which now was checked in the recently widened channel at a point farther north than previously.

The transition of the delta sands into the marine fossiliferous clays proves that the latter were chiefly composed of the mud poured into the sea by the glacial streams. I have not been able to find fossils in the clays very near the marine deltas and apparently the inflow of cold, muddy, fresh water exterminated marine life near the mouths of the glacial rivers. The small amount of erosion accomplished by the waves of the sea is elsewhere noted. Eroded till can have furnished but a small proportion of the great sheets of silt and clay, which cover a large part of Maine up to 230 feet. Logically the marine clays ought almost wholly to be classed among the glacial sediments. But the clay portions of the marine deltas of neighboring glacial rivers often coalesce, so too the delta-clays are mixed with some clay derived from till eroded by the waves. Hence it is difficult to map the delta-clays, and for the present I confine the term marine deltas to the coarser sediments (gravels and sands) spread over the sea bottom by the glacial streams. Yet it ought distinctly to be admitted that the so-called Champlain clays of Maine are almost wholly a marine off-shore deposit of Gletscher-milch, such as must be forming off much of the Greenland coast to-day.

3. *The broad Osars or Osar-plains.*—All the longer gravel systems of Maine take the form, at the northern ends, of the

y osars or two-sided ridges. Going south from five to
-five miles we find in many cases the ridges having rather
ateral slopes expand into level-topped plains up to a
le in breadth. These plains are usually, but not always,
composition than the narrow ridges of which they are
ension. Measured transversely the tops of these plains
rizontal, but measured length-wise, the broad osars are
to go up and over hills just like the osars. In numer-
stances the osar-plains have been deeply eroded by
and boiling springs. A common type of erosion is
a central ridge has been left uneroded, also a terrace on
de of the original plain. Thus two valleys have been
wn into the plain, one on each side of the axial ridge.
ntral ridge has the same height as the lateral terraces,
times it is higher. The material of the ridge is coarser
at of the rest of the plain. A good example of an
osar-plain is found in the towns of Woodstock, Milton,
mford, on the line of the great gravel system that ex-
rom the upper Androscoggin Lakes to Portland. Here
-plain extended across the whole valley of a stream
northward into the Androscoggin River. Its average
is from one-fourth to one-third of a mile. The plain is
eply eroded so as to leave an alluvial terrace on each
the valley and a prominent central ridge widely known
Whales-back. A great glacial river here flowed from the
coggin Valley at Rumford Point, southward over a
at North Woodstock more than a hundred feet higher
Rumford. The osar-plain is composed of sand near
rd, and becomes coarser as we approach the divide at
Woodstock, from whence the glacial stream flowed
he valley of the Little Androscoggin River.

mode of formation of the broad osars was approxi-
as follows. Firstly a ridge of gravel was deposited in
w channel between ice walls. We need not now inquire
r this was a sub-glacial tunnel or a superficial channel
wn through the ice to the ground. By degrees this
l enlarged laterally by the melting and erosion of the
il at last it became several, sometimes many times as
s the original channel. It is very common to find the
at the sides of the osar-plain much less water-worn than
und in the central parts. This points to much less
water action when the stream was widest. The broad
ldom if ever are overlaid with bowlders having till-

It appears incredible there should be a sub-glacial
l a half mile wide, overarched by ice, yet the sediment
g no till bowlders fallen from the roof. Whatever we
f the narrow glacial rivers as to their being sub-glacial

or superficial, I regard the broad channels as having been open on the top to the air.

Several of the longer osar-systems change to the form of osar-plains for a distance of five to forty miles, and then return to their original form of the two-sided ridge with arched cross-section. Thus the two developments—narrow and broad osar—alternate in the course of the same gravel system. The topographical relations of the two are the same.

The diagnosis of the osar-plain has come slowly to me. In the earlier years of my exploration all alluvium found in the bottom of valleys was at once classified as valley drift, and was supposed to have no direct bearing on the question of the glacial sediments. It was almost shocking to begin to suspect that the credentials of the valley drift had not all been written out, so great is our veneration for geological terms. The object of this paper is not to deal with original data. But the osar-plains are so important a class of glacial sediments that it may be well to depart from the rule and give a brief description of a concrete sample.

A nearly continuous osar begins in the vicinity of the Sebois lakes and passes south and eastward past Patten to Sherman, where for a time the gravel nearly disappears on the top of the divide between a stream flowing northward into the Mattawamkeag River, at Island Falls, and the Molunkus stream which flows nearly south into the Mattawamkeag at Kingman. The proof is positive that a large glacial river flowed from the north to the head of the Molunkus valley. Naturally this river ought to have flowed down the valley. For ten miles below Sherman we find the Molunkus bordered by a low plain of sand and fine gravel. This plain extends across the bottom of the valley from hill to hill, just like a sheet of ordinary river alluvium. We shall notice, however, that the stones of the gravel are more worn and rounded than is common in the beds of Maine streams except among the mountains where there is a fall of seventy-five feet per mile or more. As we tramp this plain for about ten miles the appearance of the deposit remains like valley drift and probably we shall become more and more convinced that it is valley drift and nothing more. Then we shall find our gravel plain going obliquely up out of the bottom of the valley and for the next ten miles taking the form of a terrace up to one-fourth of a mile wide, situated on the east side of the river at a height of fifty to seventy-five feet above it. This gravel terrace is on the average at least one-fourth of a mile from the river. From the point where the gravel plain leaves the river and goes up on to the hillsides there is no gravel along the Molunkus all the way to Kingman, only silt. Nor is there any gravel terrace on the west side of the river corresponding to this on the east side. At Macwawhoc our gravel terrace becomes a two-sided plain and soon expands into a plexus of reticulated ridges enclosing kettle-holes. The ridges here are composed of very round cobbles and bowlderets. Approaching Kingman the gravel plain narrows to a two-sided ridge of sand.

It thus becomes certain that the sand and gravel situated on the east side of the Molunkus stream for the lower twenty miles of its course could not have been deposited by any ordinary stream and is of glacial origin. The argument now stands as follows: A large river flowed in an ice channel from the north to the head of the Molunkus valley. It is also proved that a glacial river flowed through the lower part of this valley. Such a stream cannot appear or disappear suddenly by accident. The stream in the lower twenty miles of the valley must have been the same that flowed to the head of the valley. But in the upper ten miles the only gravel is that plain in the bottom of the valley looking like valley drift. The shape of the gravel stones is now explained and we see why the alluvium of the valley changes when the osar-plain goes up on to the hills. The alluvial plain of the Molunkus for the ten miles below Sherman is not valley drift but an osar-plain happening to occupy the bottom of a valley.

It may be added that this gravel system extends from Kingman near eighty miles southward to Columbia. We are considering a very long and large glacial river.

From this and numerous other examples it can be confidently affirmed that osar-plains are often found extending across the bottoms of valleys like river alluvium. There are in Maine special facilities for proving these plains to be of glacial not fluviatile origin. Thus the courses of the longer osars and osar-plains lead most of them across several valleys of natural drainage. It can thus be easily proved that there is a great change in the character of the alluvium of these valleys at the points where the gravel systems enter or leave the valleys. The shapes of the gravel stones and various other phenomena also furnish tests, but it requires a considerable study of the till, the glacial gravels, and the valley drift of a region to safely apply these tests. In long north and south valleys, like that of the Connecticut, where the course of the glacial nearly coincided with that of the post-glacial river, some of these tests cannot be applied, and it will be much more difficult to distinguish osar-plains from valley drift than it is in Maine.

The osar-plains I esteem of more geological significance than perhaps any other form of glacial sediments because of the light they throw on the mystery of the valley drift.

It is not probable that the narrow channels of the osars broadened to those of the osar-plains by lateral erosion and

melting that proceeded at an equal rate throughout th
length of a long glacial river. This broadening mus
have been recessive, i. e., gradually extending northwa
so, the broad plain that was deposited in this newly
channel was, with respect to the glacial river which
north still flowed in a narrow channel, a frontal plain.

On the north side of hills crossed by the channels of
cial rivers there was a reach of water rising to the to
hill lying to the south which was in equilibrium. Th
in fact formed a series of dams or lakes in the course
rivers. The sediments deposited in these reaches of
dead water were very characteristic and the phenom
found almost everywhere. The traces of these dams a
obvious in the osar-plains than in the narrow osars.

What are elsewhere termed narrow marine deltas a
have been deposited in channels of the ice which, if a
level, would contain osar-plains. Though narrow
pared with the fan-shaped delta yet these channels we
broad as compared with the kame and osar-channe
other words an osar-plain deposited beneath the sea
the narrow marine delta.

9. *The reticulated kames.*—As before stated, a pl
reticulated ridges enclosing kettle-holes is found at t
ward end of the marine and lacustrine deltas. So
reticulated ridges might be considered merely as a fe
the deltas and not deserving classification as a distinct
deposit. But reticulated ridges are found unconnect
deltas or only very remotely. Hence I consider them
well entitled to be recognized as a peculiar type of sedime

The plains of reticulated kames are mostly found
broader valleys and rather level regions situated betw
and 600 feet above present sea-level. They are most
ant where the local rocks are granite, though not abse
the slate areas. They are especially large and numerou
southwestern part of the State. Here they may be fo
and even twenty miles in length and from one-half a
to three or four miles in width. All degrees of con
are represented, from the great plains just mentioned
the simple case of a ridge forking into two branche
after a time come together again and thus enclose
The plains consist of a jumble of every possible kind
and heap, enclosing all forms and sizes of hollows, from
sions a foot in depth up to lake basins, which often
visible outlets.

And not only do we find ordinary narrow kame rid
nected by cross ridges, after the manner of the usual p
reticulated ridges, but there are broad plains or series o
lated kames which anastomose over large areas and

es several or many miles in diameter. Thus in that part of
e west of Sebago Lake and south of the Androscoggin
r, all the larger gravel systems are connected with each
r, not only at the great marine deltas (the deltas of the
al rivers are here so large that those of adjacent rivers
sced) but above the contour of 230 feet we find each
el series connected with the rest by lateral series. The
remarkable of these reticulations of the plains themselves
ound in the towns of Fryeburg, Brownfield, Porter, Hi-
Cornish, Parsonsfield and Newfield. The country is very
. The principal streams of the region, the Great and
e Ossipee Rivers, flow in east and west valleys, while their
al tributaries occupy a series of north and south valleys.
series of gravel plains, each from one-sixteenth to three-
ths of a mile wide, traverse this region along the north
south valleys, thereby crossing all the east and west valleys.
course leads them in several places up and over hills more
200 feet high, measured on their northern sides, and in
case over a hill about 400 feet high. Every few miles the
h and south series are connected by transverse gravel plains
imilar character. Most of these lie in the east and west
ys, but part of them go over hills. The complexity of the
reticulations can only be appreciated by inspection of the
. The gravel plains in question take the form of osar
s alternating with reaches of plains composed of reticu-
l kames. In three places they are connected with the
t kame-plains mapped by Mr. Warren Upham as extend-
in New Hampshire from Conway southward.

y paper on the kames of Maine read before the Boston
ety of Natural History in 1880 made it certain that the
er gravel systems of Maine often have branches converg-
oward the south like tributaries of the ordinary rivers that
southward. It is now certain that many osars and osar-
s divide into branches which diverge toward the south,
the delta branches of rivers. This does not refer to
ches which presently came together again (the phenom-
of the reticulated kames) but to branches that diverge for
distances and some of them end in marine deltas ten or
miles apart. In these cases the branches do not come to-
er at any place after divergence. This can be accounted
n different ways.

It is probable that in case of some of the diverging or
branches, the rivers which deposited the diverging lines
ravels flowed simultaneously in both the channels like the
branches of the Mississippi.

In some places one of the lines of diverging gravels is
d following a slope of natural drainage, while the other
over hills at a higher level. Such for instance are the

diverging osars and osar-plains found at North Waterford, also at the southeast angle of Hogback mountain in Montville, and in the valley of Break-neck brook in the northeastern part of Baldwin. In these and other similar cases the most probable interpretation is that the glacial river for some reason changed its course, so that the two lines of gravels were not formed simultaneously. Probably the channel first in use was the one leading over the higher ground. When the lower channel was opened the old one over the hills would gradually be abandoned. Yet the ice conditions were so far independent of the shape of the ground that it will be unsafe to affirm that the most favorable land-slope would in all cases be the most favorable route for a glacial river.

We may have, then, in the course of a single long gravel system, the glacial sediment taking the form of the osar, the osar-plain, and the plain of reticulated kames, also the marine and lake deltas. All are the work of the same glacial river acting under different local conditions. While it is impossible to treat of the more purely theoretical questions in a single paper, yet a few words as to the relations of these different deposits and their probable origin will be added.

The first trace we have of the long glacial river is that it deposited the osar. This proves that it flowed in a rather narrow channel—about 300 feet or less in width. All the facts in Maine, as well as those observed by Prof. Dana in the Connecticut valley, point to a larger and larger flow of water as we near the end of the ice period. This enlarging glacial river gradually broadened its channel, partly by melting of the ice at the sides, and partly by erosion. If the enlargement of the channel took place fast enough to afford passage for the waters, a broad channel was formed in which the level-topped broad osars were deposited But on long, steep down slopes, especially in the granitic regions where the englacial till was very abundant, vast quantities of sediment were swept down the slopes into the valleys and plains. The glacial channels in the valleys were rapidly filled with sediment. This, together with the great increase in the flow of the waters, forced the glacial rivers to form new channels. In other words, since the conditions were those of extraordinary sedimentation, there was not time to enlarge a single channel so as to carry off the waters, but large numbers of narrow channels were formed, connected at frequent intervals one with another by transverse channels. In these reticulating channels the reticulated kames were deposited. It should be noted that these remarks apply only to the reticulated kames not closely connected with marine or lacustrine deltas. No doubt the two classes of ridges are often intimately mixed.

According to the above stated hypothesis the reticulated ines neither connected with the deltas nor with those local ains that were deposited in small lakes or pools where the acial streams were partly stopped, were formed in channels ithin the ice, while in the delta plexus the reticulated ridges ere formed in front of the ice, so that the gravel collected the stiller water at the sides of the swift current.

It is probable that a large part but not all the reticulating e-channels were sub-glacial.

Some additional considerations relating to the origin of the ticulated ridges are the following:

1. In the case of the deposits here termed deltas, we have a adual change of sediments from coarser to finer. This is oof of a gradual slowing of swift waters, such as must hap-n when a rapid stream flows into a large body of rather still ater. But in the case of the plains of reticulated ridges und above 230 feet, we can follow them for several or many iles and find but very little sign of horizontal assortment of diments. The largest deltas below 230 feet show a decided ange in fineness within two or three miles.

2. Wherever we find the horizontal gradation from coarser finer sediment, we also find in going in the same direction e ridges growing broader (somewhat in fan-shape) and the teral slopes more gentle till the ridges coalesce in a rolling ain. But many of the osars fork into two or more branches hich continue of nearly uniform size for two or three miles l they unite again.

3. Take the case last cited of long diverging branches en-osing a space one-fourth mile wide. If the space between e branches was open water, how can we account for the pro-gious size and swiftness of the stream which swept so wide d long a space clear of sediments and left a ridge on each le of it, yet permitted the deposit of a single ridge both to e north and south of the double-ridge? In such a case it ems to me impossible that the space enclosed between the dges was kept clear of sediment by flowing water. The ar-ment seems to be overwhelming that it was occupied by ice.

There seems to be no other way to account for all the facts cept on the hypothesis that there were two classes of reticu-ted ridges, one formed in branching ice-channels, the other open water where swift streams flowed into it.

10. *Osar Border-clays.*—In several places a kame or osar bordered on each side by a plain of grayish clay which in me cases rises in a steep bank above the adjoining ground in aces where we can admit no recent erosion sufficient to count for such a terrace. So, too, such clay plains are und going over hills where no surface stream can have

flowed, not even the swollen rivers of the valley drift epoch. These conditions prove that the clay was deposited in a channel between ice walls. The central gravel ridge proves that originally a glacial stream flowed in a narrow channel and deposited a kame or osar. Later the channel broadened so as to become an eighth of a mile wide or somewhat wider. The border-clays were deposited in channels resembling those of the osar-plains, but they all belong to the shorter gravel systems. In the case of the longer glacial rivers the flow of water was moderately swift, so that a plain of sand and gravel was laid down in the broad channel. When the supply of water was small the flow became so slow in the broad channels that the finer sediment was dropped. This clay flanks and overlies the sides of the central ridge, or in some cases appears to pass into by degrees and to stand at the same level.

As there are some advantages in confining the names kame and osar to ridges of the coarser sediments, I give this bordering clay a special name, though in fact it is genetically a broad-channel deposit like the osar-plains. In both, the central part of the plain is coarser than the material at the sides.

In Madison and Anson a plain of the border-clay is strewn with quite a number of bowlders up to six feet in diameter, or somewhat more. These bowlders show no sign of water-polish on their surfaces and have the till-shape. But there is no sheet of till overlying the clay, only these occasional erratics. They were probably dropped from small bergs or ice-floes floating on the glacial stream.

11. *Frontal Plains.*—These are plains of sediment brought by glacial streams down to the extremity of the glacier and then spread sub-aerially over the land in front of the ice. The sediment extends across the bottom of the valleys in which it is found, and thus with respect to these valleys, is a form of valley drift. In Maine the frontal plains or deltas are found in valleys having a southward slope and at an elevation of more than 230 feet. They form the southern terminations of rather short osars. The osar ridge widens as we go southward and soon expands into a plain that extends across the whole valley. The stones are very much water-worn, and thus have the shapes found in the glacial gravels but not in the beds of streams, except the very steep mountain streams. Within a few miles we pass beyond the gravel and coarse sand and find the valley covered with a deep sheet of silt and clay. These so-called frontal plains are found in only a few places in Maine and are situated sixty or more miles back from the coast. They must have been formed late in the ice age when the ice had melted over the coast region. Both the frontal plains and the marine and also the lacustrine deltas, were deposited in front of the ice, but under different circumstances.

Much of the so-called Valley Drift.—The deposits hereto-
cribed are so unmistakably of glacial origin that I antici-
difference of opinion on this point among those who study
s in the field. We now approach a class of sediments
ing which the interpretation is more doubtful, and
y more facts may be needed before we solve the
in its details. It is but justice to add that my con-
have been very slowly formed and even yet are in
tative.

re was the material derived from that forms the thick
of alluvium which cover the bottoms of most of the
alleys of New England?

is sediment was derived from post-glacial erosion of the
if the deposition of the alluvium took place after all the
melted, we ought now to find the marks of this erosion.
nce the alluvium was deposited in the larger valleys,
sion must have taken place in the steeper lateral valleys
the higher hill-slopes. Ravines of erosion in the till
to abound on all the highlands, and their aggregate
ought to be very great in order to account for so large
as the valley drift. Now there are multitudes of
of erosion on the hill-sides and in the upland valleys,
y are mostly small. Each year it has appeared more
ore improbable that the existing ravines represent the
sion required by the hypothesis that the valley drift is
post-glacial erosion of the till. Nor do I see any proof
obliteration of ravines such as must have been formed.
it admissible to postulate, in so hilly and uneven a
as Maine, any great diffused or general ablation from
ole surface of the till, taking place after the ice had all
. The contour of the surface is such that surface
necessarily gather into rills and these into larger
s, thus largely localizing the erosion in ravines

he valley drift is chiefly composed of the finer parts of
. If this fine detritus was washed out of the till after
al melting of the ice and deposition of the till in its
sition, we ought now to find in the upland valleys and
great masses of residual gravels composed of the coarser
of the till left after the removal of the finer matter to
he valley drift. No such extensive bodies of coarse
l matter are found in such positions as ought to occupy
n this hypothesis.

problem resolves itself into this: How can we account
ery great erosion of the finer matter of the till, yet so
d over the surface as not to leave very large erosion
and masses of residual gravels?

subject is too complex to properly present within the
of a single article. The outlines are as follows:

1. The phenomena of the osar-plains prove that not infrequently broad channels existed within the ice up to a half mile or more in width. Within these channels great rivers deposited plains of nearly horizontally stratified gravel and sand. These are purely glacial sediments.

2. In numerous instances these broad channels extended across the valleys in which they were situated. In such cases the plains of glacial sediment cover the whole bottom of the valley from one side to the other. They thus occupy the position natural to fluviatile drift and are indistinguishable from it except by tests involving the study of many facts. The osar border-clay is a collateral phenomenon of the same class.

3. In like manner osars of unmistakably glacial origin expand into plains that soon extend across their valleys after the manner of valley drift. These are the frontal deltas or plains.

4. In general the alluvium of valleys parallel with the direction of ice flow is considerably coarser in composition than that of valleys transverse to this direction, and the stones are much more water worn.

5. The larger of the present rivers poured great quantities of sediment into the sea while it stood at the contour of 230 feet or thereabout. This apparently was cotemporaneous with the first flow of the rivers in their present valleys, after the ice had become so far melted as to permit them. The coarser fluviatile sediments at that time brought into the sea are now found in the form of broad sheets of sand which extend twenty or more miles south of the contour of 230 feet. These fluviatile sands may be termed fluviatile deltas to distinguish them from the off-shore deposits of the glacial rivers. All of them end before reaching the present shore unless the delta of the Androscoggin be an exception. For example, the Kennebec River of valley drift time poured into the sea in or near Madison and the fluviatile delta-sands of that time form a sheet one or more miles in width, which overlie the marine fossiliferous clays and extend as far south as Waterville. If during the retreat of the sea to its present level the Kennebec had continued to pour as large quantities of sand into the sea as it did while its mouth stood near 230 feet, we ought now to find a sheet of sand one to three miles wide covering the marine clays all the way southward to the present coast. Instead, we find only a small amount of fluviatile delta-matter south of Waterville, and this forms only a narrow strip near the river and is hardly distinguishable from the present flood-plain of the river. This proves that it was only while the sea stood at or near 230 feet that the swollen rivers of the Valley Drift epoch were able to transport large amounts of sediment. The shortness of this period is proved by the limited amount of erosion wrought by the sea.

e have, then, to consider not only the thick sheets of
ium covering the bottoms of the valleys above 230 feet,
also the fluviatile off-shore sands deposited at the same
. These are now exposed for our examination. Alto-
er they represent a very large body of sediment. And we
proof that it was all laid down within a very brief period.
his vast amount of fine sediment was derived from the till
the ice had all melted, we could not fail to find the
ies and other traces of this enormously rapid erosion. The
nds ought to have been dissected into a condition ap-
ching that of the bad-lands of the west.

he most probable interpretation from these and many other
is the following:

hile it is true that the morainal matter contained in the lower
ion of the ice must often have been irregularly distributed in
equence of local causes, yet on the average it is probable that
roportion increased near the ground. During the final melt-
a larger quantity of till would each year become exposed on
surface of the ice. During the melting of the last 100
very little clear water could have escaped from the ice.
surface was covered with muddy till. The sub-glacial
els were roofed with muddy ice and the same muddy ice
revealed in the walls of superficial channels and crevasses.
melting of each minute ice grain unlocked more mud.
rains and melting waters washed away this unconsolidated
far more easily than they could erode till already com-
ed and settled. Erosion accomplished by waters issuing
beneath is a very different process from ordinary erosion
rains and streams. Moreover this erosion was more de-
lent on the ice-conditions than on the slopes of the under-
g land surface. Here, then, was an ablation diffused over
whole surface. While post-glacial erosion of previously
sited till would be largely localized in the steeper lateral
eys, late glacial erosion would be far more diffused. The
ser or residual matter of the till would be left over the
le surface, not in the ravines and smaller valleys.

is a well known law of melting ice that the parts quickest
ned of their melting waters melt slowest. So on the melt-
ice-sheet, wherever the waters gathered, there the melting
eeded most rapidly. This is the principal cause of the
t enlargement of the river channels from those of narrow
to broad osar-plains.

he facts in Maine reveal very much of the hydrography
he ice-sheet. It is impossible here to go into details or to
uss the effect of hills on the overlying ice-surface. We
also to consider the effect of the till that accumulated on
ice-surface in consequence of the melting of the upper ice,
rotecting the ice beneath it from the heat of the sun and

thus retarding the melting. The net result of all the forces involved was that the waters were diverted into the valleys during the last days of the ice-sheet. The ice in contact with the water melted more rapidly than the ice of the uplands which was readily drained. The time came when the streams extended across the whole of the lower part of the valleys while much ice still remained on the hillsides. We might call the vast streams, which then filled the valleys, ordinary rivers, since they were not bordered immediately by ice. Yet the seepage of ooze and flow of Gletschermilch, silt and sand, which had helped fill the broad channels of the osar-plains period, still continued from the uplands with even greater rapidity. At the place of deposition over the bottoms of the valleys this drift was fluviatile, but with respect to the ice that still remained on the uplands it was frontal matter.

In large part the valley drift is a frontal plain of glacial sediment. In several of the north and south valleys the central part of the plain of so-called valley drift is an osar-plain proper. Given a broad channel and a more rapid melting of the ice at the sides of the channel as we go southward, it is evident that at some point the stream will have broadened so as to extend across the whole bottom of the valley. All the sediment below this point will be a frontal plain with respect, both to the osar-plain river flowing from the north and also with respect to the multitude of small streams and seeps from the ice on the hills at the sides of the valley. As the enlargement of the glacial channel proceeds northward, the frontal plain is extended at the same rate. We thus have sediments that were deposited along the axis of the valley between ice walls ultimately flanked and more or less covered by frontal matter. It will usually be very difficult to distinguish the osar-plain from the frontal plain, since they blend one into the other by degrees.

The writer has not explored the upper portion of the valley of the Connecticut River and therefore cannot venture a positive opinion. But the descriptions of the alluvium of this valley given by Messrs. Hitchcock, Upham and Dana are not only consistent with there having been an enlarging ice-channel along the axis of the valley, but are highly suggestive of that hypothesis. The alluvial drift of the lower course of the Aroostook River and the middle course of the St. John has very nearly the same character, with perhaps a larger admixture of frontal matter.

The osar-plains also help us solve the question, long mooted, of the origin of the river terraces.

It will be noted that the above outlined conception of the Valley Drift epoch, though derived from a strict induction from the facts as observed in Maine, is in many respects not very different from that of Dana's Manual.

r. XVI.—*The Direct determination of Bromine in mixtures of alkaline Bromides and Iodides*; by F. A. Gooch nd J. R. Ensign.

ntributions from the Kent Chemical Laboratory of Yale College.—IV.]

a recent paper from this laboratory* two methods were borated for the direct determination of chlorine in mixtures lkaline chlorides and iodides. These methods are based upon action of oxidizing agents, in presence of free sulphuric acid, n dilute solutions of the haloid salts at the boiling temperae. Under conditions properly controlled, iodine is entirely minated by volatilization, leaving the chlorine combined and disturbed. In the work of which this paper is an account e have endeavored to determine the applicability of the same actions to the separation of bromine from iodine in similar ociation. It appeared very early in the work that the exact nditions which were found suitable in the separation of lorine and iodine are inappropriate to the separation of bromine and iodine. Thus, while according to one of the two methods which we discuss, the gas evolved from 2 grms. of odium nitrite, passed into a solution containing in 400 cm^3 0·5 grm. of potassium chloride, 1 grm. of potassium iodide, and 5 cm^3 f strong sulphuric acid, eliminated the iodine with a mean error f 0·0002 grm. +, and while according to the other process the odine was removed by the action of 2 grms. of ferric sulphate and 3 cm^3 of nitric acid upon a solution similarly onstituted otherwise with a mean error of 0·0001 grm., it was found that like conditions in certain experiments in which potassium bromide replaced the chloride were productive f errors amounting to from 0·0100 grm. to 0·0200 grm. in both processes. It was evident, therefore, that the reactions which obtained in these processes must be carefully studied nd adjusted to make them applicable to the separation of bromine and iodine. Attention was turned at the outset to the behavior of the bromide taken by itself—that is, unaccompanied by an iodide—in boiling solutions containing the reagents of the process. Measured portions of solutions of potassium bromide and of the other reagents were brought to definite volume and boiled in a distillation flask connected with a condenser. The measured distillate was treated with silver nitrate after the addition of a few drops of sulphurous acid to convert free bromine to hydrobromic acid, and, after the addition of an excess of nitric acid to dissolve precipitated sulphite, the silver bromide was settled, filtered off upon asbestos n a perforated crucible, dried and weighed. The details of these experiments are given in the accompanying tabular statement.

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* Gooch and Mar, this Journal, xxxix, 293.

H_2SO_4 [1:1] cm³.	HNO_3 cm³.	KBr taken. grm.	= HBr. grm.	Initial volume. cm³.	Final volume. cm³.	AgBr found in the distillate. grm.	= HBr. lost. grm.
				I.			
10	--	1	0·6799	400	300	0·0001	trace
10	--	1	0·6799	300	200	0·0003	0·0001
10	--	1	0·6799	200	100	0·0006	0·0003
10	--	1	0·6799	100	50	0·0024	0·0010
10	--	1	0·6799	50	25	0·0196	0·0084
				II.			
--	3	1	0·6799	600	500	0·0002	0·0001
--	3	1	0.6799	500	400	0·0001	trace
--	3	1	0·6799	400	300	0·0002	0·0001
--	3	1	0·6799	300	200	0·0004	0·0002
--	3	1	0·6799	200	100	0·0019	0·0008
--	3	1	0·6799	100	50	0·0224	0·0096
				III.			
10	3	1	0·6799	600	500	0·0008	0·0003
10	3	1	0·6799	500	400	0·0004	0·0002
10	3	1	0·6799	400	300	0·0010	0·0004
10	3	1	0·6799	300	200	0·0018	0·0008
10	3	1	0·6799	200	100	0·0170	0·0073
10	3	1	0·6799	100	70	color of bromine in distillate	
				IV.			
10	2	1	0·6799	400	300	0·0012	0·0005
10	3	1	0·6799	400	300	0·0016	0·0007
10	4	1	0.6799	400	300	0·0034	0·0015
10	5	1	0·6799	400	300	0·0094	0·0040
10	10	1	0·6799	400	300	0·0312	0·0130

H_2SO_4 1:1] cm³.	HNO_3 cm³.	HBr taken. grm.	= KBr grm.	Initial volume. cm³.	Final volume. cm³.	AgBr found in the distillate. grm.	= HBr lost. grm.
				V.			
--	--	0·6799	1	300	200	trace	trace
--	--	0·6799	1	200	100	0·0009	0·0004
--	--	0·6799	1	100	50	0·0007	0·0003
--	--	0 6799	1	50	25	0·0004	0·0002
--	--	0·6799	1	25	15	0·0004	0·0002
--	--	0·6799	1	15	5	0·0423	0 0180
				VI			
10	--	0·6799	1	300	200	0·0009	0·0004
10	--	0·6799	1	200	100	0·0011	0·0005
10	--	0·6799	1	100	50	0·0012	0·0005
10	--	0·6799	1	50	25	0·0064	0·0027
10	--	0·6799	1	25	10	color of bromine in distillate	
				VII.			
--	5	0·6799	1	600	500	trace	trace
--	5	0·6799	1	500	400	0·0002	0·0001
--	5	0·6799	1	400	300	0·0018	0·0007
--	5	0·6799	1	300	200	0·0032	0·0014
--	5	0·6799	1	200	100	0·0202	0·0086
--	5	0·6799	1	100	90	color of bromine in distillate	

VIII.

HNO_3	$Fe_2(SO_4)_3$	HBr taken.	= KBr	Initial volume.	Final volume.	AgBr found= in the distillate.	HBr lost.
cm³.	grm.	grm.	grm.	cm³.	cm³.	grm.	grm.
5	2	0·6799	1	600	500	0·0021	0·0008
5	2	0·6799	1	500	400	0·0036	0·0016
5	2	0·6799	1	600	500	0·0037	0·0016
5	2	0·6799	1	500	400	0·0082	0·0035

om the experiments of series I, it becomes plain that 5 of strong sulphuric acid (added as 10 cm³ of the mix made by diluting the strong acid with an equal volume of r) and 1 grm. of potassium bromide do not interact in a to set bromine free or to volatilize hydrobromic acid apably until the volume of the liquid has decreased by boilto about 100 cm³. The results of series II show, in like ner, that the effect of 3 cm³ of nitric acid—the amount h was found to be suitable in the separation of iodine and ine in presence of a ferric salt—is not significant until iquid is concentrated to 200 cm³. The combined effect of two acids, as shown in the experiment of Series III, is what different. Here it is evident that bromine is liberat the highest degree of dilution employed, though the is hardly significant in a volume of liquid larger than cm³. In the experiments of series IV, the effect of insing the proportions of nitric acid, while keeping the ant of sulphuric acid and the degree of change in dilution tant, was manifestly to magnify the decomposition of the obromic acid.

series V to VIII, hydrobromic acid was employed instead e bromide. From the results of series V, it becomes evithat concentration of the pure hydrobromic acid may be ed to 15 cm³ without incurring serious loss. The effect of presence of sulphuric acid in raising the limit below which volatilization of hydrobromic acid begins appreciably, is in the figures of series VI. Series VII sets the volume of m³ as the limit to which the same amount of hydrobromic may be concentrated without loss in presence of 5 cm³ of c acid. Series VIII indicates unmistakably that even at a me of 500 cm³ the combined influences of sulphuric acid, c acid and ferric sulphate taken in the amounts named ve bromine, the loss being greater when the sulphuric is present than is the case when the nitric acid and ferric hate are present without it.

he general indication of all these results taken together brought into comparison would seem to be that improvet in the processes for separating iodine by the use of the reas whose action is here studied should lie in the direction of ter dilution of the solution treated. Accordingly certain experiments were undertaken following the same general plan already laid down, excepting that the original volume of the liquid boiled was taken much larger than before, and the concentration guarded. Determinations were first made in blank:—that is to say, the process was completed in all respects as if iodine were present and to be separated, excepting that no iodide was introduced. To the solution of the bromide, weighed in an Erlenmeyer flask of 1200 cm³ capacity, were added 10 cm³ of sulphuric acid [1:1], and, after diluting to at least 600 cm³ of water, the gas from 2 grms. of sodium nitrite was passed into the liquid, the trap consisting of an abbreviated calcium chloride tube with two bulbs, was hung in the neck of the flask, and the boiling was continued for at least an hour and a half. Finally the solution was cooled, treated with silver nitrate, and the silver bromide precipitated was settled, filtered off on asbestos in a perforated crucible, dried and weighed. The details of treatment are given in the table.

TABLE IX.

H_2SO_4 [1:1]	$NaNO_2$ used in generator.		KBr=HBr taken.		Initial volume.	Final volume.	Time in minutes.	AgBr=HBr found.		Error in HBr.
cm³.	grm.		grm.	grm.	cm³.	cm³.		grm.	grm.	grm.
10	2		0·5394	0·3667	800	500	120	0·8506	0·3665	0·0002−
10	2		0·5387	0·3663	700	400	90	0·8492	0·3659	0·0004−
10	2		0·5397	0·3669	600	400	90	0·8511	0·3667	0·0002−
10	2		0·5397	0·3669	600	400	90	0·8488	0·3657	0·0012−
10	2		0·5369	0·3650	600	400	90	0·8465	0·3647	0·0003−
......	$Fe_2(SO_4)_3$ +	HNO_3	.....	.....	....	....	....	.....	.....	....
	grm.	cm³								
10	2	5	0·5384	0·3662	800	500	105	0·8494	0·3661	0·0001−
10	2	5	0·5384	0·3662	800	500	105	0·8483	0·3655	0·0007−
10	2	5	0·5371	0·3652	600	400	90	0·8455	0·3643	0·0009−
10	2	5	0·5363	0·3645	600	400	90	0·8439	0·3636	0·0009−

It is obvious that so far as the treatment in blank is concerned the degree of dilution had been reached at which no significant volatilization of the bromine takes place. We proceeded, therefore, to make the actual separation, the only change in conditions being the addition of 0·5 grm. of potassium iodide, which was especially prepared and used in solution as described in the paper to which reference has been made. The boiling was continued until red litmus paper, moistened and held in the escaping steam for a minute or two, showed no reaction for iodine.

TABLE X.

H_2SO_4 [1:1]	KI.	$NaNO_2$ used in generator.		KBr=HBr taken.		Initial volume.	Final volume.	Time in min.	AgBr=HBr found.		Error in HBr.
cm³.	grm.	grm.		grm.	grm.	cm³.	cm³.		grm.	grm.	grm.
10	0·5	2		0·5371	0·3652	600	500	20	0·8358	0·3601	0·0051—
10	0·5	2		0·5367	0·3647	600	500	30	0·8337	0 3592	0·0055—
10	0·5	2		9 5365	0·3647	600	500	20	0·8309	0·3580	0·0067—
....	....	$Fe_2(SO_4)_3 + HNO_3$		.....	.....	....	....	....	.....	.....	....
		grm.	cm³								
10	0·5	2	5	0·5373	0·3653	700	550	75	0·8170	0·3520	0·0133—
10	0·5	2	5	0·5375	0·3655	700	550	60	0·8171	0·3520	0·0135—

In the comparison of the results of these experiments with those of Table IX, it is plain that, though the time of exposure to the boiling temperature is much shorter, the evolution of the iodine is attended by a not inconsiderable disappearance of bromine. This loss is greater in those tests in which the oxidation is produced by the combined action of nitric acid and the ferric salt. It is plain that in this form the method is useless. We tried next the effect of reducing the quantities of the reagents used by one-half, keeping the volume of the liquid the same, and, finding that the process, conducted otherwise exactly as described above, yielded under these new conditions 0 1825 grm. of hydrobromic acid instead of 0·1827 grm. taken, we began a series of experiments designed to test the effect of varying the amounts of sulphuric acid present. The other conditions were kept unchanged. Table XI contains the record of experiments of this sort in which the oxidizing effect was secured by the action of nitric acid and a ferric salt. In Table XII are given the results of experiments in which the fumes generated by the action of sulphuric acid upon sodium nitrite were passed into the liquid to set the iodine free.

TABLE XI.

H_2SO_4 [1:1]	KI.	$Fe_2(SO_4)_3 + HNO_3$.		KBr=HBr taken.		Initial volume.	Final volume in cm³.	Time in min. approximate'y	AgBr=HBr. found.		Error in HBr.
cm³.	grm.	grm.	cm³.	grm.	grm.	cm³.			grm.	grm.	grm.
5	0·5	2	3	0·5514	0·3748	650	500	90	0·8285	0·3570	0·0178—
4	0·5	2	3	0·5510	0·3745	650	500	90	0·8378	0 3610	0·0135—
3	0·5	2	3	0·5514	0·3748	650	500	90	0·8463	0·3647	0·0101—
2	0·5	2	3	0·5504	0·3741	650	500	90	0·8521	0·3672	0·0069—
1	0·5	2	3	0·5508	0·3744	650	500	90	0·8554	9·3686	0·0058—

TABLE XII.

H_2SO_4 [1:1]	KI.	$NaNO_2$ used in generator.	KBr=HBr taken.		Initial volume	Final volume.	Time in minutes.	AgBr=HBr found.		Error in HBr.
cm³.	grm.	grm.	grm.	grm.	cm³.	cm³.		grm.	grm.	grm.
5	0.5	2	0·5374	0·3654	600	never less than 500	Ab't 30	0·8460	0·3645	0·0009—
5	0·5	2	0·5375	0·3655	600	....	...	0·8447	0·3639	0·0016—
5	0·5	2	0·5365	0·3647	600	....	....	0·8473	0·3651	0·0004+
5	0·5	2	0·5361	6·3644	650	....	....	0·8461	0·3645	0·0001+
5	0·5	2	0·5106	0·3471	650	....	....	0·8070	0·3478	0·0007+
5	0·5	2	0·5506	0·3743	650	....	....	0·8645	0·3725	0·0018—
4	0·5	2	0·5371	0·3652	650	....	....	0·8466	0·3647	0·0005—
4	0·5	2	0·5377	0·3655	650	....	....	0·8473	0·3651	0·0004—
4	0·5	2	0·5508	0·3744	650	....	....	0·8676	0·3737	0·0007—
3	0·5	2	0·5371	0·3652	650	....	....	0·8459	0·3644	0·0008—
3	0·5	2	0·5365	0·3647	650	....	....	0·8465	0·3647	0·0000
3	0·5	2	0·5368	0·3649	650	....	....	0·8486	0·3656	0·0007+
3	0·5	2	0·5364	0·3646	650	....	....	0·8471	0·3650	0·0004+
3	0·5	2	0·5505	0·3742	650	....	....	0·8690	0·3744	0·0002+
3	0·5	2	0·0576	0·0391	650	....	....	0·0915	0·0394	0·0003+
3	0·5	2	0·0552	0·0375	650	....	....	0·0883	0·0380	0·0005+
2	0·5	2	0·5366	0·3647	650	....	....	0·8478	0·3654	0·0007+
2	0·5	2	0·5369	0·3650	650	....	....	0·8472	0·3651	0·0001+
2	0·5	2	0·5515	0·3747	650	....	....	0·8687	0·3742	0·0005—
1	0·5	2	0·5367	0·3648	650	....	....	0·8494	0.3660	0·0012+
1	0·5	2	0·5366	0·3647	650	....	....	0·8490	0·3658	0·0011+
1	0·5	2	0·5368	0·3649	650	....	....	0·8492	0·3659	0·0010+
1	0·5	2	0·5515	0·3749	650	....	....	0·8763	0·3776	0·0027+

It is plain that in both processes the loss of bromine diminishes as the amount of sulphuric acid decreases. In the presence of nitric acid and ferric sulphate the point is never reached, within the limits of our experimentation, at which the error is brought within allowable bounds. This mode of attempting the separation of bromine and iodine we therefore abandoned.

On the other hand the nitrous acid process, fairly successful when the sulphuric acid present is restricted to 5 cm³ of the half and half acid (or to 2·5 cm³ of the strong acid), is established as trustworthy when the sulphuric acid present is held within the limits of 2 cm³ to 4 cm³ of the [1 : 1] mixture. The mean error of thirteen determinations in which the proportions last mentioned were preserved is 0, lying between extremes of 0·0008 grm. —and 0·0007 grm. +. When the quantity of sulphuric acid is still further diminished there appears to be a slight tendency to show an apparent excess of the bromide, due in all probability to the retention of a little combined iodine in the solution. The best proportion for practical use is probably 3 cm³ of the half and half acid to an initial volume t less than 600 cm³—the amount lying midway between the)portions with which divergences begin to be noted.

Other test determinations were made along the same lines, :epting that, instead of generating the nitrous fumes outside ; liquid under treatment, pure sodium nitrite was introduced ectly into the solution. The nitrite was prepared free from logens by adding to its solution a little silver nitrate, acidu- ing distinctly with nitric acid, and filtering off the little 'er chloride thus precipitated, together with a small amount silver nitrite thrown down at the same time. The strength the solution thus prepared was determined by acting upon efinite portion with ferrous sulphate in excess and titrating residual ferrous salt with potassium permanganate. The ails of these experiments are given in Table XIII.

TABLE XIII.

KI	$NaNO_2$ in the liquid.	KBr=HBr taken.		Initial volume.	Final volume.	Time in minutes.	AgBr=HBr found.		Error in HBr.
grm.	grm.	grm.	grm.	cm³	cm³		grm.	grm.	grm.
0·5	0·35	0·5508	0·3745	650	never below 500 cm³	About 30	0·8689	0·3744	0·0001 —
0·5	0·35	0·5513	0·3747	650	......	......	0·8694	0·3746	0·0001 —
0·5	0·35	0·5513	0·3747	650	......	......	0·8699	0·3748	0·0001 +
0·5	0·35	0·3005	0·2042	650	......	......	0·4746	0·2045	0·0003 +
0·5	0·35	0·2759	0·1875	650	......	......	0·4358	0·1878	0·0003 +
0·5	1·75	0·5513	0·3747	650	......	......	0·8705	0·3750	0·0003 +
0·5	1·75	0·5510	0·3746	650	......	......	0·8707	0·3751	0·0005 +

'he mean error of these seven determinations is 0·0002 ı. +, lying between the extremes 0·0005 grm. + and 0·0001 ı. —. In the first five of these determinations enough ite was employed to break up one and a half times the ɔunt of iodide taken, if the action is supposed to go to the nt of setting NO free. In the last two experiments, eight es the quantity of the nitrite theoretically thus called for was en with no apparent change in the effect.

That iodine may be removed with reasonable accuracy from ctures of iodides and bromides without disturbing the bro- ıe is evidently established; and, inasmuch as the proportion which the reagents are taken in the corresponding process the separation of chlorine from iodine lie far within the its found applicable to the bromine separation, it would be ural to suppose that in the presence of a chloride associated h the bromide the sum of the hydrobromic and hydrochloric ls would be given with exactness under the conditions suitable for the estimation of the former. We deemed it best, however, to submit this point to the test of experiment. The result substantiates the presumption.

TABLE XIV.

H_2SO_4 1:1	KI	$NaNO_2$	KBr	KCl	Theory for AgCl + AgBr	Found AgCl + AgBr	Error in silver salt.	Error calculated as HBr	Error calculated as HCl
cm^3	grm.	grm.	grm.	grm.	grm.	grm.	grm.	grm.	grm.
3	0·5	0·35	0·5517	0·4981	1·8280	1·8262	0·0018–	0·0008–	0·0006–
3	0·5	0·35	0·5511	0·4980	1·8268	1·8253	0·0015–	0·0005–	0·0004–

It is plain, in conclusion, that of the two methods which we have studied, though both are applicable to the separation of chlorine from iodine, but one is utilizable for the separation of bromine from iodine, and that under modified conditions. With the necessary modifications, however, it is good, and easily applied. It may be briefly summarized as follows: The neutral solution containing the bromide and iodide is diluted to 600 cm^3 or 700 cm^3 (instead of 400 cm^3, which was found to be a sufficient dilution in the case of the separation of chlorine from iodine), 1 cm^3 to 1·5 cm^3 of strong sulphuric acid, or, better, 2 cm^3 to 3 cm^3 of the mixture made by diluting the acid with an equal volume of water, (instead of 10 cm^3 of the 1 : 1 mixture employed in the chlorine separation), are added, a sufficient amount of pure sodium or potassium nitrite is introduced, (or, if it is preferred, the gas generated by the action of dilute sulphuric acid upon the ordinary nitrite and introduced from the outside may be employed instead,) and the liquid is boiled, after trapping the flask as described, until the color has vanished and the escaping steam no longer gives to red litmus paper the color characteristic of iodine. The residual liquid is treated with an excess of silver nitrate, and the precipitated bromide filtered off, dried, and weighed. The process of boiling need not extend beyond a half hour, or a little more, and care should be taken that the volume of the liquid shall never be less than 500cm^3. We have not dealt with quantities of the potassium bromide and iodide larger than 0·5 grm. each, approximately. The presence of 0·5 grm. of potassium chloride does not affect the sharpness of the separation.

ʟʀᴛ. XVII.—*Some Lower Silurian Graptolites from Northern Maine*; by W. W. Dᴏᴅɢᴇ.

ɪɢʜᴛ years ago I pointed out a newly found graptolite lo-
y in Penobscot County, Maine,* about seventy-five miles
h of Bangor and twelve east of Mt. Katahdin. I have
ɜ obtained a few additional specimens there, and now re-
them for the evidence they give as to the age of the
s in which they occur.

he entire list of determinable forms before me is as fol-
:

1. *Helicograptus gracilis* Hall (sp.)
2. *Dicellograptus?*
3. *Diplograptus*, n. sp.
4. *Cryptograptus marcidus* Hall (sp.)
5. *Glossograptus spinulosus* Hall (sp.)
6. *Young graptolite.*

his is clearly a fraction of the Norman's Kill assemblage
pecies.

o. 1 is represented by a single specimen, incomplete but
nct and showing well the 'peculiar proximal bar.' It was
n from an extensive ledge that lies along the south bank
he Wassatiquoik, about a mile above the junction of that
ım with the east branch of the Penobscot. Thin layers of
tolite-holding shale are separated by considerable thick-
es of highly siliceous slate that varies in color from olive-
to deep blue-black.

he specimens of No. 2 are too obscure for certain recog-
n even of the genus. The hydrothecæ are undistinguishable.
branches have the double curvature that in different de-
s is shown in several species of Dicellograptus, but they
ot include an angle agreeing exactly with that assigned to
of the described species.

he best specimen of Diplograptus yet obtained was found
881 north of the stream, in a free, angular piece of shale,
was then mentioned as *D. pristis*. It differs in some
iculars from *D. pristis* His., as described by Tullberg.†

he free portion of the outer margin of its hydrothecæ is
sually long, equalling three-quarters of the width of the
pary, ($1\frac{3}{5}^{mm}$: $2\frac{2}{5}^{mm}$). The specimen has fewer hydrothecæ
given length of polypary than any described species,‡

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his Journal, Dec., 1881, vol. xxii, p. 434.

ihang till Kongl. Svenska Vetenskaps-Akademiens Handlingar, Bd. vi, No.
. 10, 11, taf. 1.

. *peosta* excepted, if necessary; description of which I have not been able
sult. For the name, see Wisconsin Geological Report 1862, p. 430.

only sixteen in an inch, six in ten millimeters. *D. longissimus* Kurck * (Upper Silurian) has seven hydrothecæ in ten millimeters; they overlap each other more than do those in the Maine specimen, and terminate differently. *D. foliaceus* Murch.,† has eighteen to thirty in an inch, and is wider. *D. euglyphus* Lapw.,‡ for which a different marginal angle of the hydrothecæ is stated, has eighteen to twenty-four. *D. rugosus* Emmons § has twenty and a wider polypary. *D. pristis* has nine or ten in ten millimeters and has a small radicle.‖ The Maine specimen agrees nearly with *D. pristis* and *D. longissimus* in the angle between the outer margin of the hydrothecæ and the central line of the polypary. It has a radicle two millimeters long.

The precise level at which this probably new species occurs relatively to the other specimens has not yet been ascertained.

4. *Graptolithus marcidus* Hall, has been treated as identical with *Cryptograptus tricornis* Carr. (sp.). Prof. Hall's figure shows no essential difference. *C. tricornis* has parallel lateral margins. In all distinct and entire specimens, from fifteen to forty millimeters long, that I have seen, from Hudson River valley localities, there is well marked distal convergence of the margins. The convergence sometimes begins or becomes more rapid at a point distant perhaps six times the maximum width of the polypary from its proximal extremity, that is about one-half or one-third of its length, and thus is seldom conspicuous in the proximal half of the polypary. A slight proximal convergence also is frequently or usually noticeable. Prof. Hall's figure may represent a specimen which had lost part of its polypary. The few parallel-margined New York specimens that I have seen are small (with pointed distal extremity¶) or imperfect.

I think *C. marcidus* should be retained for the present.

The Maine specimen is from the same piece of shale with the Diplograptus above mentioned (No. 3.) The slightness of the test characteristic in Cryptograptus makes the specimen inconspicuous, but it is easily recognizable after the attention is directed to it.

5. The specimens of Glossograptus were obtained from the same ledge as No. 1, but from a higher layer of shale. They are very indistinct. The spines appear to be in number about ten on each side. The polypary, exclusive of the spines, is

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* Geol. För. i Stockholm Förh., Bd. vi, Heft 7, p. 302, taf. 14, figs. 8, 9.

† Sil. Syst., Pl. xxvi. f. 3. Hopkinson and Lapworth in Quart. Journ. Geol. Soc. Lond. 1874, xxxi, p. 657.

‡ Ann. and Mag. Nat. Hist., (5) v, p 166.

§ American Geologist p. 105, Pl. 1, fig. 26.

‖ Tullberg, op. cit., p. 10.

¶ Like fig. 17, Plate B, of Graptolites of the Quebec Group.

sixteen millimeters long and three or three and one-half wide. The spines are three millimeters long, directed somewhat distally and a little reflexed. So far as the specimens can be made out, they agree well with Prof. Lapworth's figure of the ventral aspect of *G. Hincksii* Hopk. (sp.).* The species of this genus require revision, but its American representatives are not yet fully known.

At the localities near Albany, beside a very abundant Glossograptus which is perhaps a small form of *G. ciliatus* Emmons, there is an oddly irregular shaped form, that in some respects approaches *G. pinguis* Hopk. (sp.).† Figure 16 of Plate B, Graptolites of the Quebec Group, seems to represent this peculiar graptolite in a spineless condition and small.

No. 6 somewhat resembles Mr. Carruthers' figure of the young form of *Cryptograptus tricornis* Carr. (sp.),‡ but is a little longer in proportion to its width, and the sides do not diverge quite so rapidly. I have no opinion to express as to its relations.

The Graptolite compared in 1881 to *Dicranograptus ramosus* probably can not be identified. There is no Phyllograptus among my specimens.

Cambridge, Mass.

Art. XVIII.—*Siderite-basins of the Hudson River Epoch;* by James P. Kimball. With Plate VI.

The Taconic region on the borders of western New England and eastern New York has ceased to be the debatable ground it once was, thanks to Prof. James D. Dana and to collaborators in special parts of the same field—notably, the late Rev. A. Wing on the limestone region of Vermont, Prof. W. B. Dwight in Dutchess County, N. Y., and the excellent work of C. D. Walcott. The unity of the limestones with the Calciferous, Chazy and Trenton formations, appearing in widely different aspects at intervals over this extensive area; the identity of its associated series of shales, grits, sandstones, etc., with metamorphic products like fissile slates, hydro-micas, schists, quartzites, and even gneisses; and the relations of part of the schists with the Hudson River group of strata have been set forth by Professor Dana in a remarkable series of memoirs contained in this Journal from the years 1873 to 1888, inclusive. The recent work by C. D. Walcott, toward locating the Cambrian and other points has removed all remaining doubts as to the general age of the rocks.

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* Graptolites of County Down, Proc. Belfast Naturalists' Field Club, 1876-7, Appendix IV, plate vi, fig. 24*a*.

† For the opportunity to study this and a number of other interesting graptolites, some of which will probably prove to be new or previously unknown in New York rocks, I am indebted to the kindness of Mr. Charles Schuchert.

‡ Trans. Roy. Phys. Soc. Edinburgh, 1858, p. 468, fig. 2; Annals and Mag. Nat. Hist. (3), iii, p. 25; Geol. Mag. 1868, V, Plate V, fig. 11*b*.

The association with the same strata of siderite or clay ironstone, or, as more widely distributed, residues *in situ* of its weathering decomposition, has also been pointed out with reference to the geographical and stratigraphical occurrence of limonite beds throughout the same region.

A recent study of the iron-ore bodies in course of very active and systematic development by the Hudson River Ore and Iron Company since the year 1875 at Burden, Columbia County, N. Y., affords a number of interesting facts not unimportant in their bearing on the still rather obscure structural geology of the western margin of the Taconic area extending to the Hudson River, and indeed on the geology of the whole Taconic belt.

Sections from the river to the vicinity of Johnstown, on the New York and Albany turnpike, traverse the Hudson River shales to the base of the heavy body of fissile slates covering the western foot-hills of the Taconic range, with fine exposures by excavations and diamond drill of the intervening calcareous grits and ferriferous limestone beds, including in places basins of siderite in unaltered form. The stratigraphical relations of at least this horizon of iron ore are easily established. The probability of its unity with a definite horizon of other well known occurrences of ferriferous material in altered or weathered form in numerous parts of the development of the same series of strata is indicated by several circumstances, such as appertain to an expansive bottom whether littoral or marine.

The iron-ore basins referred to are about a mile east of the Hudson, between Catskill and Germantown railway stations, a few degrees north of west from Copake, or directly opposite that point in a line, that is, at right angles to longitudinal axes of flexure in this part of the Appalachian system. The intervening ground is occupied by a series of minor folds whose longitudinal axes conform to the parallelism of the same system. The ore-basins, four in number, constitute a chain. Their longer axes are likewise parallel to the trend of the Taconic and Catskill ranges. All but the first or most southerly basin, and the terminal southern part of the second or next basin to the north, have been folded and elevated into anticlinals whose western and middle zones have been completely eroded to give place to the bed and terraces of the Hudson. With the exception noted, the parts of the basins still preserved are in monoclinal dips to the east, and expire under cover by attenuation. The broken or basset edges of the ore-beds outcrop on the west slope and near the crest of a line of prominent ridges, the first from the river, known as Mt. Thomas, Cedar Hill and Plass Hill. The several basins have thus been elevated into what previous to the sculpturing of the immediate valley of the Hudson was a range of anticlinals of which the remnants are still prominent landmarks. The thickness of the ore-beds along the escarpment formed by this outcrop varies according to the relations of the line of obliterative erosion with different sections of lenticular bodies, as well as to the expanse and depth of the original basins of deposit. For all are distinctly lenticular in shape when referred to their uneroded condition, and considered as remnants of a whole which corresponded each to a cast of its original basin. The disrupted edge of the ore-body of the second basin (in order from south to north), in the crest of Mt. Thomas is near 600 feet above the river and about 44 feet in maximum thickness. Similar escarpments in the third or Cedar Hill basin expose a thickness of 30 feet of ore, and in the fourth or Plass Hill basin, 8 feet. The thickness of the filling of each basin is proportional to its original expanse approximately determined by a horizontal projection of the anticlinal arch. The first, a small basin, is wholly submerged though at a shallow depth. This has been partially exhibited by excavations along its upturned edge, and its extent determined by diamond drill. Though bodily lifted upon the flanks of an anticlinal, mostly eroded, this ore-body preserves the configuration of a basin and, like all the basins, is faulted and thrown in minor degree. It has entirely escaped erosion.

The floor of all the basins is gray argillyte weathering into brown shales, of Hudson River age, according to the earlier views of Prof. W. W. Mather and Prof. James Hall, sustained by Mr. T. Nelson Dale's discovery of fossils of that group in the same formation near Poughkeepsie.* This is the lowermost formation brought to the surface in this part of the Hudson River valley, and forms the beds of that river and of the lower parts of its eastern affluents in Columbia County. It was penetrated in boring No. 1 to a depth of 662 feet, from an elevation 222 feet above the river, the total depth of this boring being 987 feet. Overlying conformably the Hudson River shales is a thin belt of limestone intercalated with argillaceous shales, and continuous with calcareous grits, forming the roof of the ore-basins. Numerous sections of this within the compass of the first and second basins have been obtained by use of the diamond drill.

* This Journal, xvii, 1879, p. 377.

These show a greatly expanded but variable thickness as well as an increased variety in the composition of the sediments, all of which are transitional, that is, both calcareous and ferriferous. The same belt is brought to the surface farther east by bosses and anticlinals, in one case reversed. A line of low bluffs has been sculptured from the same range of elevations 1·14 miles east of Mt. Thomas. The local sections referred to, compassing near 1300 feet of strata, including the siderite basins, may be concisely presented as follows:

	Maximum thickness.
Dense fissile slate at base of Taconic hills. Probable equivalent of metamorphic (hydro-mica) slates further east. Weathering white.	+ 200 ft.
Brecciated ferro-calcareous sandstone	161
Ferro-calcareous sandstones, passing into conglomerate	120
Aphanitic black argillyte, intercalated with arenaceous shale	50
Ferro-calcareous grits, seamed with calcite	48
Siderite: clay-ironstone, passing into sub-crystalline spathic carbonate	44
Gray argillyte, weathering into drab shale. Bluffs of east bank of Hudson River. Boring No. 1	+662

The grits capping the ore basins merge into thin-bedded limestone in the intervals between the basins, as well shown on the line of their axes along a stretch of low bluffs continuous with the Mt. Thomas and Cedar Hill ore-escarpments. The contact of the limestone with the underlying shales or floor of the ore-basins, is in these intervals close and barren. The contact, similarly exhibited in the second or eastern range of exposed bosses and anticlinals, is likewise close and barren, but the calcareous grits still prevail instead of thin-bedded limestone, as if the marine currents intermittently supplying the coarser grits had an easterly course. Overlying grits and limestone the members are of the character of hydrous fissile slates. These form the surface east of the monoclinals which elevate the ore-basins, their first appearance east of the Hudson being at the base of the first range of monoclinal hills. These slates, probably representing the hydro-mica slates of the metamorphic area to the east are very persistent, especially in the foot-hills of the Taconic mountains where their great massiveness may be partially due to replication, reverse dips or overthrown anticlinals occurring even west of Johnstown, as shown by inferior strata.

The correlations of this fragment of Lower Silurian geology are distinctly with the same field of structural and stratigraphical work described by Prof. Dana in the memoir already cited. The series of strata here described are probably all of the Hudson River epoch, and little altered by metamorphism, though on the western border of the Taconic area.

The ore-basins themselves are not without remarkable characteristics. They may be described as a series of beds of clay-ironstone intercalated with mechanical sediments, all more or less calcareous as well as ferruginous. While, on the one hand, in the southern portion of the second basin well under cover, the iron-stone has been metamorphosed into sub-crystalline spathic siderite, weathering decomposition, on the other hand, has wrought the partial alteration of all exposed parts of the beds into limonite. Metamorphism of amorphous ferrous carbonate into spathic siderite appears to be due to the unimpeded crystallization of such parts of the deposits as were the freest from siliceous admixtures in the form of mechanical sediments. That this has resulted from a condition of exceptional purity is well shown by numerous analyses as well as by the fact of the absence of crystallization from parts of the deposits richer in siliceous matter. All the familiar phenomena of alteration of iron-stone into limonite are well exhibited in weathered parts of all the basins, especially exfoliation of hydrous ferric oxide with the elimination of silex and clay. These insoluble residuums are sometimes preserved *in situ* as contents of drusy cavities.

This remarkable series of ore-basins seem to owe their origin to depressions on an in-shore mud bottom fed by waters from decomposing basic rocks. From such waters ferric oxide was precipitated along with mechanical sediments from the land and calcareous sediments from the sea. Currents and occasional perturbations introduced detritus, while vegetable and animal life found conditions favorable for existence in degree inversely to the predominance of ferric precipitate. This is indicated by the presence in the ore of phosphoric acid in inverse ratio to the proportion of iron, the metamorphic or spathic ore of the southern part of the second basin alone being below the Bessemer limit in phosphorus, and up to the shipping standard in units of iron. Submergence of the basins by rapid accumulation of sediments, and probably also by subsidence below the range of atmospheric action was followed by decay of buried organic matter attended by reduction of ferric to ferrous oxide, whence ferrous carbonate in the presence of carbonic acid and absence of atmospheric oxidation. To some extent, also, carbonate of lime has probably been replaced by carbonate of iron.

Senft's theory of the formation of argillaceous iron-ores through saturation of sedimentary beds with ferrous bi-carbonate, and the formation away from atmospheric oxidation of insoluble ferrous carbonate, while perhaps adequate to explain certain occurrences of thin deposits and alternations of clay iron-stone, notably in the coal measures, in circumstances of emergence, fails to satisfactorily account for its formation on a large scale under conditions distinctly pointing to submergence.

The following analyses of unaltered ores of both types, after calcination, are selected from the company's file of numerous commercial analyses: I, spathic siderite from No. 2 mine, by Mr. A. S. Bertolet, of Crown Point; II, iron-stone from Mt. Thomas, both from different parts of the second basin:

	I.	II.
Ferrous oxide	2·78	
Ferric oxide	68·23	65·73
Magnesia	7·07	5·72
Alumina	2·27	3·01
Lime	3·36	4·35
Phosphoric acid	0·06	0·3188
Silica	11·65	17·18
Manganous oxide	2·92	2·66
Sulphur	0·62	0·78
	99·96	99·75
Metallic iron	49·92	46.70

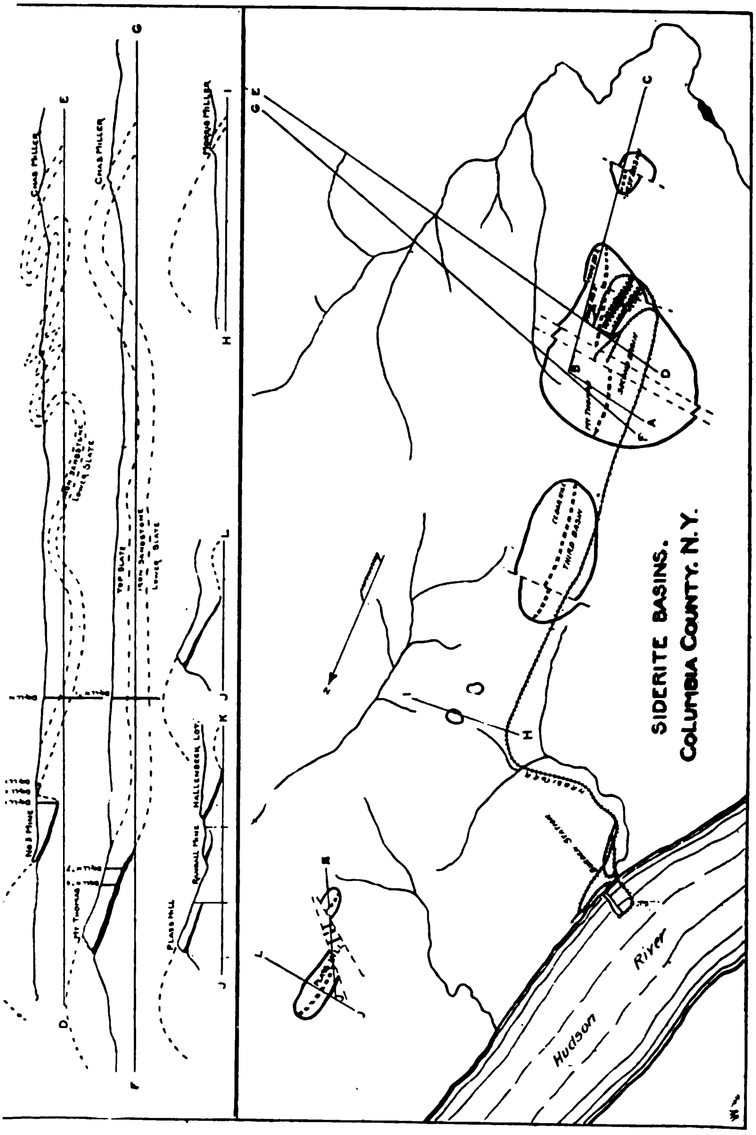
The low proportion of alumina in contrast with the large proportion of magnesia will not fail to be noticed. This is remarkable throughout the whole series of analyses. The detrital derivation of the earthy admixtures from basic—notably hornblendic rocks as prevailing in the Archæan highlands—need scarcely be pointed out in explanation of this peculiarity of these unaltered paleozoic iron-stones.

Washington, 26th April, 1890.

ART. XIX.—*On a new variety of Zinc Sulphide from Cherokee County, Kansas;* by JAMES D. ROBERTSON.

A NEW and peculiar sulphide of zinc was found in southeastern Kansas a short time since, remarkable from the fact that it is nearly pure white and completely amorphous.

This singular mineral is found on the Moll Tract in the center of the town of Galena, Cherokee County, Kansas. The ore body, which is reached by a shaft about 90 feet in depth, consists of zinc blende with some large crystals of galena distributed through it. It is about 25 feet wide, 20 feet high, and 100 feet long, so far as explored. The blende has undergone much decomposition from the action of surface waters, the sulphide oxidizing to sulphate and being completely removed in solution. Thus no calamine or smithsonite are formed and the siliceous gangue rock remains, a cellular mass, showing casts of the dissolved blende crystals. In the center of the ore body and surrounded on all sides by partially decomposed ore, is a flat opening three to four feet wide, six


SIDERITE BASINS.
COLUMBIA COUNTY, N.Y.

ches to a foot in height and filled completely with the white nc sulphide. When taken from the mine this substance is ft, full of water, and resembles in appearance and constency white lead ground in oil. It has a very slight reddish ıst, probably from a little ferric oxide. Some red tallow ays overlie the deposit. In a shaft about 250 feet distant, ear the same level, a much larger body has been exposed in ıe floor of the workings. This mass of sulphide of zinc has ot been developed but is at least four feet in thickness and tends for a distance of thirty feet. Evidences point to uite an extensive body of this peculiar ore of zinc in this ine.

An analysis made by the St. Louis Sampling and Testing Vorks shows the following composition on the dried sample:

Insoluble matter	2·52
Zinc	63·70
Sulphur	30·77
Ferric oxide	2·40
	99·39

The water which was contained in the original sample botled on the ground showed a slight amount of sulphuric acid.

This sulphide was evidently formed since the deposiion of the ore by the precipitation of the sulphate of zinc, esulting from the oxidation of ordinary blende by sulphueted hydrogen or an alkaline sulphide. No odor of sulphueted hydrogen was perceptible in the mine nor was any ound in the water which saturated this sulphide of zinc. his mineral has never, it is believed, been met with before, he conditions which would thus imitate the reactions of the boratory not being common in nature.

RT. XX.—*Two new Meteoric Irons;* by F. P. VENABLE.

1. *From Rockingham County, N. C.*

THIS mass was reported to have fallen about the year 1846, ar the old "Mansion House," Deep Springs Farm in Rockgham Co., N. C. One of the old negro servants related to r. Lindsay, the present owner of the farm, that "the rock ll on a clear morning and struck the ground about a hundred rds back of the garden. It frightened every one very much. ol. Jas. Scales, the owner of the farm at that time, and Mr. illard took a man and went to the spot and dug in about four five feet and got it out." It lay about the house as a curiosity for several years when it ceased to be of any more interest and was thrown aside. After Mr. T. B. Lindsay bought the farm, he kept the meteoric mass for several years upon his porch. In the fall of 1889 he presented it to the State Museum. The indentation in the earth where it is reported to have struck is still pointed out.

The weight of the mass was 11·5 kilos. It had somewhat the outline of a rhomboid, measuring $270^{\mathrm{mm}} \times 210^{\mathrm{mm}}$ (extremes) and having a thickness which varied from 10 to 70^{mm}. It is coated with oxidation products to a depth, in places of several millimeters. These give the whole mass a dull reddish brown color. The surface is irregularly pitted with broad, shallow pits. It is somewhat concave on one side. On being polished and etched it gave faintly the Widmanstätten figures. It belongs to the class of sweating meteorites, beads of deliquesced ferric chloride appearing on the surface. This lawrencite, so-called, is evidently unevenly distributed through the mass. Analyses from different portions gave different amounts of chlorine. In one boring it was noticed that the metal near the surface (within 2^{cm}) gave a decided percentage of chlorine, while that coming from the deeper part of the drill hole (3–5^{cm} from surface) gave no appreciable amount of chlorine.

The analysis gave:

Fe 87·01, P 0·04, SiO_2 0·53, Cl 0·39, Ni 11·69, Co 0·79 = 100·45

2. *From Henry County, Va.*

This meteoric iron was found by Nathaniel Murphy in Henry County, Va., about four miles from the Pittsylvania County line, and one-half mile north of the dividing line between North Carolina and Virginia, near to Smith River. Murphy found the stone in a ploughed field in the latter part of the spring of 1889. He gave it to Col. J. Turner Morehead of Leaksville, N. C. Together with Col. Morehead he searched over the farm, but could find nothing similar to this piece. Col. Morehead sent the mass to Dr. H. B. Battle of Raleigh, N. C. It weighed 1·7 kilos and the detached pieces, mainly crust, weighed 0·22 kilos. This crust broke off along certain lines by a sort of cleavage, and the main mass is permeated with cracks, not irregular and zig-zag, but as distinct and regular, almost, as if it were a piece of crystallized gypsum. This cleavage is in two directions. The laminæ vary in thickness, but many are about $\frac{1}{2}^{\mathrm{mm}}$. The color of the surface is dark bluish-black mixed with much red-rust coming from the lawrencite. Parts of the soil apparently still clung to the mass. It measured $60 \times 70 \times 75^{\mathrm{mm}}$ taking the greatest lengths in the three directions. Here and there spots were to be seen with

it silvery sheen. It contains a good deal of ferric chloride
is rapidly crumbling. On polishing down one of the sides,
Widmanstätten figures (coarse) came out very plainly, no
ing being necessary.
ne analysis gave:

e 90·54, Cl 0·35, SiO_2 0·04, P 0·13, Co 0·94, Ni 7·70=99·70

versity of North Carolina, May, 1890.

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

On the Nature of Solutions.—Pickering has continued his
stigations on the nature of solutions and now gives the re-
as deduced from the freezing point of sulphuric acid solu-
. The following are his conclusions: "The freezing points
lutions of sulphuric acid form four separate figures, each of
h represents the crystallization of a different substance. In
case where water crystallizes out, the figure consists of a
le branch curve, whereas in the cases where the tetrahydrate,
monohydrate and anhydrous sulphuric acid crystallize out,
figure consists of two curves rising up and meeting at points
sponding with the composition of the substance crystallizing
ch case respectively. The tetrahydrate as a solid, is a new
ate melting at −25°, its existence in solution having been pre-
sly established. Irregularities and sudden changes of curva-
are found in the figures. These changes occur at the same
ts as those noticed in the case of the densities, heat-capacity,
of dissolution, expansion by heat, and electric conductivity.*
he seventeen hydrates indicated by the last-named proper-
everyone has received further confirmation from the present
where such confirmation was possible (in thirteen cases);
dition to which, three others have been recognized (two of
h were, however, suggested by the previous work), thus
g the total to twenty. Sudden changes at H_2SO_4 and at
t $36H_2SO_4SO_3$ have also been established. The freezing
diagram shows that the existence of a definite hydrate may
arked by an indubitable change of curvature at the point
sponding to its composition (e. g., $H_2SO_4(H_2O)_4$ and H_2SO_4).
y of the changes are sufficiently marked to be evident with-
the aid of differentiation. The constituent portions of the
us figures are probably not parabolic. The changes at the
me end of the water-curves, with solutions containing less
H_2SO_4 to 100 H_2O, are of considerable magnitude. The
e here instead of being made up of one straight line, is made
several straight lines, the last change observed occurring

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*Noticed in the May number of this Journal.

with solutions as weak as 0·07 per cent H_2SO_4, or 0·0125 H_2SO_4 to 100 H_2O. The molecular depression shown, *even in this extreme region*, instead of being constant as it should be according to the theory of osmotic pressure, varies between 2·95° and 2·1°. The molecular depression in the various curves ranges from 0·01° to 2·95° according to the nature of the solvent and that of the dissolved substance, these numbers referring only to solutions containing not more than one foreign molecule to 100 solvent molecules. In no two cases out of the seven investigated does it possess the same value. In every case an increase in the strength of the solution beyond this proportion entails an abnormally low freezing point. According to all existing physical theories of solution the freezing points of such solutions should be abnormally high."—*J. Chem. Soc.*, lvii, 331, May, 1890. G. F. B.

2. *On the Molecular-Mass of Iodine, of Phosphorus, and of Sulphur in Solution.*—BECKMANN has applied his method of determining the molecular mass of a substance by means of the elevation which it produces in the boiling point of a solvent, to the cases of iodine, of sulphur and of phosphorus, dissolved in carbon disulphide, and to that of iodine in ether. The molecular elevation of the boiling point in the case of carbon disulphide using 100 grams was 23·75° and referred to 100 c. c. was 19·43°. In the case of ether the molecular elevation was, for 100 grams 21·05°, and for 100 c. c. 30·21°. As a result it appeared that the molecular mass of iodine, in solution both in ether and in carbon disulphide, is 254 very nearly; corresponding to the formula I_2. The molecular mass of phosphorus in carbon disulphide is 124, corresponding to the formula P_4; and that of sulphur in the same solvent is 256, corresponding to S_8.—*Zeitschr. Physik. Chem.*, v, 76, February, 1890. G. F. B.

3. *On the conditions of Equilibrium between Electrolytes.*—ARRHENIUS has compared the experimental conditions of equilibrium in solutions with those pointed out by theory. In the case of an acid and one of its salts, if x represents the fraction of dissociated acid and d the amount of the salt, V being the volume in liters containing one gram molecule of the acid and n molecules of the salt, then $(nd+x)x=KV(1-x)$, K being a constant of dissociation determinable from the conductivity of the acid. This equation is found to hold in the case of acetic and formic acids and their sodium salts. Since for feeble acids x is small, and may be neglected in comparison with nd or 1, and since d is practically independent of the dilution, it follows that the degree of dissociation, that is, the strength of a feeble acid when a salt is present in the same solution, is proportional to the amount of the salt. Between a feeble acid such as acetic, and a salt such as sodium chloride, the equilibrium is that between four substances, not only the two mentioned, but also the sodium acetate and hydrogen chloride resulting from their reaction. If the fractional dissociation of these substances in the order named be expressed by d_1 d_4 d_2 d_3, and one molecule of acetic acid on

being brought into contact with *n* molecules of sodium chloride produces *x* molecules of hydrogen chloride and sodium acetate, then $d_2x\ d_3x = d_1\ (1-x)\ d_4\ (n-x)$; a result agreeing with that given by experiment. The author shows that it is possible to deduce from this equation a value for the so-called "avidity" measured by Thomsen and Ostwald, and he finds that for monobasic acids, the avidities for any given dilution are approximately proportional to the degrees of dissociation of the acids at this dilution. This conclusion agrees with Ostwald's results. The author also points out that the theory of Guldburg and Waage is applicable only to equilibrium between four electrolytes, when two of them are strongly dissociated; and further that one of the conclusions of this theory, that the avidities of acids are proportioned to the square roots of their affinity-coefficients, is incorrect. Since the decomposition of certain salts by water, observed by Walker to follow the ordinary laws of mass action, takes place in accordance with the equation given above, it seems necessary to assume that water is an electrolyte and is partially dissociated.—*Zeitschr. Physik. Chem.*, v, 1, Feb., 1890; *J. Ch. Soc.*, lviii, 437, May, 1890. G. F. B.

4. *Coincidences between lines of different spectra.*—Professor RUNGE of the Technical High School in Hanover examines methods given by various authors for discriminating real from accidental coincidences between the lines of different spectra, and applies the result of his own analysis to Grünwald's speculation on the composition of the elements. It will be remembered that Grünwald believed that his hypothesis was most strongly supported by the agreement between the wave-lengths of the lines in the spectrum of water, as deduced by him from those of the hydrogen spectrum, and their values as obtained by observation. Professor Runge, however, finds that the distribution of differences is in perfect accordance with the one expected for an equal number of wave-lengths chosen at random. The distribution of differences gives no more reason to believe the coincidences real "than to believe in a connection between the mantissas of log sin, and the spectrum of water."—*Phil. Mag.*, June, 1890, pp. 462–466. J. T.

5. *Hertz's experiments.*—L. BOLTZMAN shows the experiments of Hertz to a large audience, even when the primary circuit is at a distance of 8·7 meters from the secondary circuit, by making the minute sparks in the secondary circuit connect the pole of a battery with an electroscope. As long as no spark passed between the terminals of the secondary circuit, the electroscope remained uncharged by the battery. When the circuits were 36·8 meters apart, it was estimated that the length of the secondary spark was $\frac{1}{5000}$ of a millimeter. The method employed by Boltzman serves also to examine interference phenomena.—*Ann. der Physik und Chemie*, No. 6, 1890, p. 399. J. T.

6. *Stationary light waves.* — OTTO WIENER, by the employment of a peculiar photographic process, has succeeded in show-

ing the existence of stationary light waves, analogous to the sound waves shown in Kundt's experiment. The author has also endeavored by his method to settle the question of the direction of the vibration of light with respect to the plane of polarization, and believes that his experiments show that these vibrations take place perpendicular to this plane. He also shows that the chemically active vibrations and the electrical vibrations are in the same plane. In other words, the chemical action of the light rays is joined to the vibrations of electrical force and not to those of magnetic force.—*Ann. der Physik und Chemie*, No. 6, 1890, pp. 203–243. J. T.

7. *Electrical Oscillations in air.*—Recent experiments in the Jefferson Physical Laboratory of Harvard University, conducted by JOHN TROWBRIDGE and W. C. SABINE, show that the medium of the dielectric exerts a marked effect upon electrical surgings or oscillations. The spark from a large air condenser was analyzed by a rapidly revolving mirror and the oscillations photographed. A marked periodicity in the time of the electrical waves was discovered when the air condenser was employed. When a glass condenser was substituted for the air condenser the periodicity became less marked. The glass evidently could not recover from the initial strain in time to interfere with the recurring electrical oscillations. In the case of air, however, the partial recovery from each electrical wave served to modify the time of the latter. The work of the authors shows that for rapid charges and discharges of an air condenser the factor expressing the capacity is a periodic function, the value of which depends upon the state of strain of the air.—*Proceedings of the American Academy of Arts and Sciences*, May 18, 1890, pp. 109–123. J. T.

II. GEOLOGY AND MINERALOGY.

1. *The American Committee* OF *the International Congress of Geologists.*—In the February number of the American Geologist (vol. v, No. 2), p. 125, is a report of a meeting of the "American Committee of the International Congress of Geologists" held in New York Dec. 26, 1889. What is meant by the name is the Standing Committee of the American Association *on* the International Congress. As there is now an American Committee of the International Congress which is known in the French language of the Congress as the American "Comité d'Organisation," and is recognized as such by the London Bureau of the Congress, and as it is necessary for this committee to act in its official capacity as the American Committee of the Congress in organizing the American Session, I beg to call attention to the misuse of the name by the Committee of the American Association.

There are three committees in America which have to do with the International Congress of Geologists, and as several gentlemen are members of all three of the committees, care is necessary not to confuse them in their official capacities.

The "Comité Fondateur," or founding committee, was appointed by the American Association for the Advancement of Science in 1876. It was composed as follows: James Hall, president; T. Sterry Hunt, secretary; W. B. Rogers, J. W. Dawson, J. S. Newberry, C. H. Hitchcock, R. Pumpelly, T. H. Huxley, Otto Torrell, E. H. de Baumhauer. To the committee were added in 1877 the names of J. P. Lesley and A. C. Ramsay.

This committee performed its function of inaugurating the first session of the Congress of Geologists at Paris in 1878, by which it was given a place of honor as *ex officio* a part of the Bureau, and was called "*Comité Fondateur de Philadelphie.*" The American representatives now living are Messrs. Hall, Hunt, Dawson, Newberry, Hitchcock, Pumpelly and Lesley. As a committee of the American Association it reported in 1879. In this year also the names of G. H. Cooke, J. D. Dana and Clarence King were added, and the European names on the list were dropped.

In 1880, the committee was formally discharged, as stated in he Proceedings of the Association for that year, vol. xxix, p. 748.

In the Proceedings for 1881, no mention is made of any committee on the International Congress.

In the volume of the Proceedings for 1882, the following entry appears in the report of the general secretary, Proc. vol. xxxi, p. 634:

"Dr. T. Sterry Hunt made a statement in reference to the International Geological Committee, of which Professors Hall, Selwyn, Lesley, and himself had been appointed representatives from North America. Several months ago a report was prepared by them. The work was not yet completed, and, on the recommendation of the standing committee, he moved that the committee be continued. The motion was seconded by Professor Hall and the committee was continued." On page xviii of the same volume, among the special committees of the Association under the title "Committee on the International Congress of Geologists" are printed the names of the American members of the committee appointed in 1876.

The "International Committee" named above, in Mr. Hunt's statement can refer only to the "International Committee on Cartography" and on "Classification and Nomenclature," appointed by the Congress. The Association had no power either to continue or discontinue them. Moreover, it was not the committee appointed by the American Association in 1876 to organize the Congress, for that committee had already performed its function, reported, and been formally discharged.

The committee, thus irregularly established, has been continued year by year by the Association. In 1884, G. H. Cook, E. D. Cope, J. W. Powell, E. A. Smith and J. J. Stevenson were added. n 1885 Persifor Frazer, N. H. Winchell and H. S. Williams were added. In 1889, the committee itself elected C. D. Walcott, Wm. B. Scott and Robert Bell to fill vacancies made by the eath of G. H. Cook and the resignation of J. W. Dawson and

J. W. Powell. So that this special committee *of the American Association* "*on* the International Congress of Geologists," now consists of James Hall, J. S. Newberry, T. Sterry Hunt, C. H. Hitchcock, Raphael Pumpelly, J. P. Lesley and the names added as above. Its officers are James Hall, chairman; Persifor Frazer, secretary; and C. H. Hitchcock, treasurer.

The third committee is the Committee *of the International Congress*, appointed by the council of the London meeting of the Geological Congress to organize an American Session of the Congress, and is technically known as the American "Comité d'Organisation," or Committee of Organization. And it is the only American Committee *of* the Congress. It is composed of the following gentlemen:

Messrs. Branner, Chamberlin, Cope, Dana, Davis, Dutton, Frazer, Gilbert, Hague, Hall, Heilprin, Hitchcock, Hunt, Le Conte, Leidy, Lesley, Marsh, Newberry, Powell, Procter, Shaler, Stevenson, Walcott, Whitfield, Winchell and Williams.

Its officers are J. S. Newberry, chairman; G. K. Gilbert, vice-chairman; and H. S. Williams, secretary. H. S. W.

2. *Professor* WM. M. FONTAINE *on the Potomac or Younger Mesozoic Flora.*—This new volume of the U. S. Geological Survey has been mentioned with high commendation by Mr. Lester F. Ward, in the last volume of this Journal. Professor Fontaine closes the volume of 377 pages, with an extended and thorough comparison of the genera and species of the Potomac flora with those elsewhere of the Jura-Trias and Cretaceous periods, and ends with thirty pages of tables, twenty of which are a further exhibition of these relations. We cite the last page preceding the tables, presenting Professor Fontaine's conclusions from the plants as to the age of the Potomac deposits.

"Taken as a whole, then, and compared with the Cenomanian flora of the Dakota and New Jersey Cretaceous strata, the angiosperms of the Potomac decidedly point to the Neocomian as the age of the Potomac beds.

"From this brief review of the flora, we see that there is in it a very large and important element that belongs to the Jurassic or typical Mesozoic flora; a less important but still large element, that has near relations in Cenomanian and even living forms; while the largest, most fully developed and characteristic element is most nearly allied to forms distinguishing the Neocomian. All the important species common to the Potomac and the floras of known formations are found in the Neocomian, including under this name both the Wealden and Urgonian. If any additional evidence were needed of the Neocomian age of the Potomac, it may be found in the peculiar union of old and new types, whose evidence, if we consider them by themselves, is contradictory. Schenk, in Die Foss. Pflanz. der Werns. Schichten, page 29, in speaking of the character of the Neocomian flora of the Wernsdorf beds, well says that the flora of the older Cretaceous occupies in the development of the plant kingdom a position similar to that of the Trias, for the forms characteristic of two great periods of development meet in it; that is, the survivors of the past period (Mesozoic) and the new forms of the approaching one (Tertiary). This being true, we should expect to find in any large collection of Neocomian plants a great mingling of types. We should find the survivors of the old floras and the newly arrived precursors of the more recent ones mingled with a number that attain their development in and are peculiar to the Neocomian. This is exactly what we find to be true of the Potomac flora. That so many of these plants are new is perhaps to be explained, in part at least, by the fact already mentioned, that the flora of this epoch is very poorly represented and comparatively but little known. It is not possible to say positively to what precise epoch of the Neocomian the Potomac belongs. Its flora ranges from the Wealden through the Urgonian, and probably includes some Cenomanian forms."

3. *Eruption of Bandai-san.* Transactions of the Seismological Society of Japan, vol. xiii, Part ii.—We have here a republication of the paper of SEKIYA and KIKUCHI (noticed in a former volume) on the remarkable eruption of Bandai-san in 1888, with its plates, and also an important paper on the same subject by C. G. KNOTT and C. MICHIE SMITH. A point of general interest in the observations discussed in the second paper relates to the condition of the forests, especially those south and southeast of the place of eruption. It is stated that the forests were subjected "not merely to a hurricane of wind, but also to a fierce cannonading of stones of all sizes from the tiniest grains to huge blocks." "The cloud of stones, largely unchecked, in their on-rush, shot over the ridge and down the steep slopes till the smaller gradients and their own accumulation brought them to a stand." "That much of it was launched horizontally so as to graze the surfaces of the ridge and high level slopes is demonstrated by the nature of the damage done to the trees." "To get some idea as to the heaviness of this bombardment we counted the separate cuts and bruises on the quarter of a square foot of the surface of a battered tree, selected as a representative one; a careful count gave 75," or "300 missiles to the square foot." "There is no reason to suppose that the vertical projection was denser than the horizontal; on the contrary, there are good reasons for supposing that the horizontal was the greater;" in other words, "the amount projected at lower inclinations than 45° far exceeded the amount projected at higher angles." "As regards the larger fragments the outburst was confined to inclinations less than 30° to the horizontal." These facts seem to make it an explosive eruption in which the explosion took place high up in the mountain. The mountain had not been in eruption for 1000 years and had lost much of its breadth in the meantime by erosion. The eruption was without the medium in any way, according to Kikuchi (which is undisputed in the second paper), of liquid lavas.

The authors discuss also the force and velocity of falling masses, taking as data the accepted Gunnery tables, and make out that, owing to the resistance of the atmosphere, a velocity of about 720 feet a second is the greatest attainable by a rough flat-sided rock, a square yard in section, and nearly 4000 lbs. in mass; "such a mass projected from a height of 8000 feet above the sea-level, with a vertical speed of 8500 feet per second, will reach a height of 24,500 feet above the sea-level; and it will return to the earth from that height with a speed of 720 feet per second, which speed it will nearly have attained after it has fallen about half this height." The object of the calculation was to prove that the numerous deep cylindrical holes in the ground were not made by the falling of stones (a view presented in a paper by Mr. Odlum) but to some other cause, probably the uprooting of trees. J. D. D.

4. *Die Mineralien der Syenitpegmatitgänge der Südnorwegischen Augit- und Nephelinsyenite;* by W. C. Brögger, 235 and 663 pp., with 27 plates and 2 geological charts. Leipzig, 1890—Zeitschrift für Krystallographie und Mineralogie, vol. xvi (Wm. Engelmann).—It would be difficult to find in the whole range of mineralogical literature another monograph of such exhaustive thoroughness, so rich in new facts and descriptions of new species and devoted to a region of such unique interest as this weighty volume by Professor Brögger. The reader is impressed more and more as he turns over the pages with the vast amount of labor here expended and the rich results which the author has attained. It is impossible here to do more than indicate in the briefest manner the scope of the work. It is divided into a general and a special part. The first part (235 pp.) takes up the geological relations of the pegmatite veins of the Christiania region, giving a general survey of the geology with the several types of eruptive rocks here developed; this is followed by an account of the geology of the syenite and nephelite-syenite veins of the special region under examination, namely that between the Christiania and Langesund fjords. This region has long figured, somewhat inaccurately, in mineralogical text-books under the name of Brevig, a place, however, which lies just outside its proper limits. This latter part of the subject carries us over a most instructive discussion of the paragenesis of the minerals peculiar to these veins.

The special portion of the work (655 pages), which forms the bulk of the volume, is devoted to the minute description of the mineral species, 73 in number. How rich this is will be in part appreciated from the fact that some ten new species are here described, while of many old species we have monographs of the first importance. Of the new species, a number have already been briefly characterized in this Journal (xxxv, 416) from a preliminary article by the author published in 1887. These are: Barkevikite, calciothorite, melanocerite, nordenskiöldine, rosenbuschite. Besides these we have descriptions of the following: Hambergite, a borate of beryllium in orthorhombic crystals; JOHNSTRUPITE, a titano-silicate of the cerium metals, calcium, sodium, etc.; it is allied to mosandrite, and near it in crystallization; HIORDTDAHLITE, a fluo-silicate of zirconium, calcium, sodium; it occurs in tabular triclinic crystals near wöhlerite in form; KARYOCERITE, a silicate containing boron, thorium, the cerium metals, calcium and others in smaller amount; occurs in rhombohedral crystals, tabular in habit; WEIBYEITE, a carbonate of the cerium metals near parisite. The descriptions of these new species are models of thoroughness, and not less valuable are the monographs on hydrargillite, the species of the thorite, sodalite nephelite, mica, pyroxene, amphibole and feldspar groups, also låvenite, leucophanite, homilite, acmite and ægirite, and many others. On the chemical side the author has had the assistance of Professor Cleve and other chemists whose many careful analyses add much to the value of the work. Mineralogists owe their thanks not only to the author and those who have directly aided him, but also to the editor and publisher of the journal of which this work forms the sixteenth volume.

5. *Catalogue of Minerals for sale by George L. English & Co.* Philadelphia, 1890.—This catalogue contains a convenient list of the species arranged as in Dana's System (with appendixes) and including also others of recent date. The volume is issued in attractive form and its value is increased by the republication of a number of papers, with figures, on copper arsenates from Utah, phenacite, bertrandite, etc. from Colorado, beryllonite from Maine, and others.

III. BOTANY.

1. *Catalogue of Plants found in New Jersey;* by N. L. BRITTON, Ph.D., Trenton, N. J., 1889, pp. 642.—Dr. Britton, of the Torrey Herbarium, Columbia College, published in 1881, a preliminary Catalogue of New Jersey Plants, and, in 1888, in conjunction with five associates, a preliminary catalogue of the flowering plants and ferns reported as growing spontaneously within one hundred miles of New York City. In the latter, the nomenclature was revised and corrected by Dr. Britton and Messrs. Sterns and Poggenburg. The present catalogue preserves the nomenclature employed in the earlier work. To the lists, Mr. Rau contributes the Sphagna, while the rest of the Bryophyta have been arranged by Mr. Rau and Mrs. Britton, after the C. F. Parker list. Mr. Rau has given also a list of Hepaticæ. Dr. T. F. Allen takes the Characeæ, and D. Eckfeldt the Lichens, basing his enumeration on Professor Tuckerman's determinations of Mr. Austin's collections. The catalogue of Marine Algæ is contributed by Mr. Martindale, and the Fresh-water forms by Rev. F. Wolle, the two lists being combined by Dr. Britton into a single series. The Diatoms are given by Professor Kain; the Fungi by Mr. Ellis and Mr. Gerard.

From Dr. Britton's interesting tables we transcribe the following data which possess much more than a local importance.

The State of New Jersey lies between the parallels of 38° 55′ and 41° 21′ north latitude, and the meridians 73° 55′ and 75° 33′ of longitude west of Greenwich, comprising somewhat above 8,000 square miles in area. Within these limits there are found:

Dicotyledoneæ	1,348		
Monocotyledoneæ	558		
Total Angiospermæ		1,906	
Total Gymnospermæ		13	
Total Anthophyta			1,919
Total Pteridophyta			76
Total Bryophyta			461
Total Thallophyta			3,021
Total Protophyta			164

The catalogue will prove useful not only to local collectors, on account of the great care with which the stations have been given but will be of service to all those who are interested in the problems of geographical botany. G. L. G.

2. *List of Plants.*—We have to note the following recent lists, mostly with annotations. (1.) A list of plants collected by Dr. E. A. Mearnes, Arizona, by Dr. N. L. Britton. In the same number is printed also a paper by Dr. Rusby on the general floral characters of the San Francisco and Mogollon Mountains of Arizona and New Mexico. Trans. N. Y. Acad. Sc., vol. viii. (2.) List of plants collected by Dr. E. Palmer, in Lower California in 1889. By George Vasey and J. N. Rose, from Proceedings of U. S. National Museum, vol. xi. (3.) List of plants collected by Dr. E. Palmer in 1888, in Southern California, by the authors of the list above noticed, also by the same, the following: (4.) List of plants collected by Dr. E. Palmer, at Lagoon Head, Cedros Island, San Benito, Guadalupe, and the Head of the Gulf of California. The two last are printed as No. 1 of the Contributions from the National Herbarium, Washington. (5.) Plants from Baja, California, by T. S. Brandagee, including supplementary papers by Dr. George Vasey, Dr. C. F. Millspaugh, Dr. H. W. Harkness, and others, Proc. Cal. Acad. Sc. ser. 2, vol. ii. (6.) Provisional list of the Plants of the Bahama Islands, by Professor John Gardiner, University of Colorado.

3. *Preparation of sections for the study of the development of organs.*—Goethart, (Bot. Zeit. June 6, 1890) makes a suggestion in regard to the use of Elder-pith for the cutting of sections which has proved useful in some rather troublesome cases. From the pith, a long vertical slice is made which fits by means of a tongue into a notch on the larger part, and thus a firm grasp is obtained for the preparation placed between the two. Around the upper part a very thin platinum wire is wound, and the whole is then placed in alcohol to harden. Exceedingly thin sections can be made in this manner; the specimens can be placed at will in any position and kept there firmly. G. L. G.

4. *On the Ascent of colored liquids in living plants.*—In Bot. Zeit., May 30, Wieler calls attention to an article by Goppelsroeder, which has not yet come directly under our hands. From Wieler's notice, it appears that a very large number of coal-tar colors can pass into the plants observed, provided the solutions are very dilute. Experiments in this direction were conducted in the Botanical Laboratory of Harvard College during the past winter, by two students, whose work is nearly ready for publication. From their studies it is plain that there is a wide difference in the power of different plants to absorb these solutions, and there are also very great differences as regards the absorption of different colors by any single plant. In some instances it has been possible to replace one color by another, provided the roots remain sound. Those cultures succeeded best in which the solutions were kept very slightly acid, as was naturally to be expected. The distribution of color in the tissues of the plants experimented on was very different, even in the same species. It has been impossible to resist the conclusion that in nearly every case the employment of the liquid introduced a disturbing factor, the effects of this disturbance being diverse. In the case of seedlings the plants were prone to yield to attacks of moulds, and speedily decay. Experimenters must keep in mind the fact that colored solutions are easily absorbed through injured roots, and, further, that plants with injured roots can live and grow slowly for a considerable time. G. L. G.

5. *Analytical Key to the Genera and Species of North American Mosses;* by Professor C. F. Barnes, Madison, Wisc. Pamphlet.—This most useful work is distinguished by its sharp lines of definition. In the few cases in which we have put it to a practical test it has made short work of difficulties. It supplements admirably the treatise of Lesquereux and James. G. L. G.

6. *Structural and Systematic Botany;* by Professer D. H. Campbell. Ginn & Co., Boston, 8vo, 253 pp. The author has taken for his work the title which Dr. Gray gave to his comprehensive treatise very many years ago, and which survives as a minor title even in the sixth edition. A cursory reading impresses us favorably, leading us to believe that the work will be useful in the hands of judicious teachers, and in much the same way as the excellent treatise by Professor Bessey. With these two works and the plain practical Plant-Dissection by Professors Arthur, Barnes and Coulter, botanical students are likely to have enough guidance of the right character. The advice in any and all of the foregoing handbooks is sound and safe, and it ought to do very much toward turning out a large number of earnest workers. G. L. G.

IV. ASTRONOMY.

1. *On the Spectrum of the Nebula in Orion;* by William Huggins and Mrs. Huggins.—A new study of the spectrum of the nebula of Orion, with improved instruments and instrumental

methods, and under more favorable conditions for observation, has enabled the authors to determine more accurately the position and character of the principal line. The position determined, corrected for the earth's motion and assuming that the nebula has no motion of its own, is λ 5004·75. A comparison with the bright line of a hydrogen vacuum tube confirmed the conclusion reached in 1874 that the nebula has very little of any sensible motion in the line of sight. It is also shown that the principal line is not coincident with but falls within the termination of the magnesium-flame band. As regards the character of the principal line it is found that it is sharply defined and presents nothing of the peculiarity of a fluting. Confirmatory observations by other astronomers are quoted, and a postscript dated June 15, states that a telegram received from the Lick Observatory announces that Mr. Keeler had confirmed, in Σ 5, the position assigned to the principal line, namely, as not coincident with but falling within the terminal line of the magnesic oxide band. It is hence certain that the chief line is not due to magnesium or its oxide.

A second paper gives some important results of an examination of new photographs of the spectrum taken March 14–17. These photographs, of almost the same part of the nebula as the photograph of 1889, showed the lines of hydrogen at *h* and at H strongly impressed upon the plate, though these lines were carefully searched for in vain in the former photographs; also the first two lines of the ultra-violet series in the white stars described in 1879. Four of these lines had been photographed in the spectrum of hydrogen by Dr. H. W. Vogel, in 1879, and the entire series, with the exception of one, has been since obtained by Cornu in exceptionally pure hydrogen. The line α at λ 3887·8 is strong, and the next line β at λ 3834·5, though much fainter, is certainly present. Between the hydrogen lines α and β there is a line stronger even than α, which has a wave-length of about λ 3868. No line is found in the photograph exactly at the place of the solar line K; the position of this line appears to correspond to a gap between two lines on the plate.

The strong line which was first seen in a photograph of the nebula taken in 1882 is certainly stronger than Hγ, and is by far the most powerful line in the photographic region, and in position it is found to be slightly less refrangible than λ 3724. It is believed the line will be found to fall between λ 3725 and λ 3726. It is certain that the line does not coincide with any one of the three components of the magnesic oxide triplet, but is less refrangible than the middle line at λ 3724, and falls between this line and the first line of the triplet at λ 3730.

A marked feature of the lines is their abruptly different intensities at different parts of their length, giving the blotchy appearance which is characteristic of the lines in the visible spectrum. These brighter blotches are sharply bounded, showing that the different parts of the nebula are distinct and become suddenly brighter than the neighboring parts. The lines of the new phographs contain two very strong and abruptly-bounded blotches, d a third one less marked. It is now evident that this differce in two parts of the lines indicates a different condition of the bula on the two sides of the star-spectra. Other lines besides ose described in this note are present, not only between G and but also on the more refrangible side of the strong line about 3725.—*Proc. Roy. Soc.*, March 20, April 16, 1890.

2. *On a new Group of Lines in the Photographic Spectrum 'Sirius;* by WILLIAM HUGGINS and Mrs. HUGGINS, (Proc. Roy. c., April 25.)—In 1879, the author gave an account of a series broad lines in the photographic region of the spectrum, characteristic of Sirius, Vega, and other white stars, and which was entified as a continuation of the spectrum of hydrogen beyond . In photographs taken since, the complete series of the hydron lines, including θ and ι, come out with great distinctness. e presence of another group of broad lines was suspected some stance farther on in the ultra-violet region, but until this year ey have not been seen in the photographs with sufficient disictness for even approximate measurement. On April 4th, a iotograph of the spectrum of Sirius was taken with a long expore, the slit being made very narrow. This plate shows that the ectrum of Sirius, after the termination of the hydrogen series, mains, as far as can now be seen, free from any strong lines itil a position as far in the ultra-violet as about λ 3338 is ached, at which place appears the first of a group of at least six ies, all nearly as broad as those of the hydrogen series. The ird line of the group about λ 3278 appears to be the broadest, it they are all broad, though even in this photograph they are t seen with the distinctness which is necessary for ascertaining curately their relative character. The sixth line occurs where e spectrum is faint, almost at the limit of this photograph, which as taken when Sirius was some distance past the meridian, and is uncertain whether this line completes the group, or whether ere may not be other lines still more refrangible belonging to

The following are the wave-lengths determined, but they ust be regarded as only preliminary, and but roughly approxiate measures of the positions of the new lines:

λ 3338 λ 3311 λ 3278 λ 3254 λ 3226 λ 3199

V. MISCELLANEOUS SCIENTIFIC INTELLIGENCE.

1. *American Association for the Advancement of Science.*—he 39th meeting of the American Association will open at dianapolis on Tuesday, the 19th of August. The meeting will the 50th anniversary of the organization of the Association of eologists and Naturalists, in whose expansion the present Assoation began its existence. The president for the meeting is rof. George L. Goodale, of Cambridge, Mass.

For all matters pertaining to membership, papers and business the Association, the permanent secretary, Prof. F. W. Putnam, ould be addressed at Salem, Mass., up to August 15; and from ug. 15 to Aug. 30, the Denison House, Indianapolis.

Dr. George W. Sloan is chairman of the Local Committee. Members of the Association arriving in Indianapolis before the meeting should call for information at the temporary office of the local secretary, Alfred F. Potts, No. 19½ N. Pennsylvania street.

The American Geological Society will hold its semi-annual meeting at the State House, on August 19.

2. *Hailstones of peculiar form;* by O. W. HUNTINGTON. (Communicated).—During a severe thunder storm at Asquam Lake, Holderness, N. H., on July 14th, there was a fall of large hailstones continuing for some 10 minutes. On examination, many of the stones proved to be sharply defined crystals having the form of a double hexagonal pyramid, resembling dodecahedral quartz; others were rounded and flattened and some had a spherical nucleus with small partially formed crystals projecting from it.

3. *Oswald's Klassiker der exacten Wissenschaften.* Leipzig, 1890. (Wm. Engelmann.)—Recent issues in this valuable series (this Journal, vol. xxxviii, 256) are the following:

No. 4. Untersuchungen ueber das Jod, von Gay Lussac (1814).

No. 5. Allgemeine Flächentheorie (Disquisitiones generales circa superficies curvas), von Carl Friedrich Gauss (1827).

No. 6. Ueber die Anwendung der Wellenlehre auf die Lehre vom Kreislaufe des Blutes und insbesondere auf die Pulslehre, von E. H. Weber (1850).

No. 7. Untersuchungen ueber die Länge des einfachen Secundenpendels, von F. W. Bessel (1826).

No. 8. Die Grundlagen der Molekulartheorie. Abhandlungen, von A. Avogadro und Ampère (1811–1814).

No. 9. Thermochemische Untersuchungen, von G. H. Hess (1839–1842).

No. 10. Die mathematischen Gesetze der inducirten elektrischen Ströme, von Franz Neumann (1845).

No. 11. Unterredungen und mathematische Demonstrationen über zwei neue Wissenszweige die Mechanik und die Fallgesetze betreffend, von Galileo Galilei. Erster und zweiter Tag (1638).

No. 12. Allgemeine Naturgeschichte und Theorie des Himmels oder Versuch von der Verfassung und dem mechanischen Ursprunge des ganzen Weltgebäudes nach Newtonischen Grundsätzen abgehandelt. von Immanuel Kant (1755).

OBITUARY.

CHRISTIAN HENRY FREDERICK PETERS, the ever active and accomplished astronomer, at the head of the Observatory of Hamilton College, Clinton, N. Y., died on the 19th of July, in his 77th year. In 1838, having two years before taken the degree of Doctor of Philosophy at Berlin, he was with von Waltershausen in his study of Mt. Etna, and afterward on the Geodetic Survey of Naples. After the revolution of 1848 he left Italy, and in 1853 came to the United States. He received an appointment from the U. S. Coast Survey, and was for a while at the Cambridge and then the Albany observatory, before his call in 1858 to Hamilton College. His laborious work of mapping the stars was rewarded by the discovery of forty-seven asteroids. In 1882 a first series of his "Celestial Charts," twenty in number, was published. His results also include observations on comets, on solar spots, on the Transit of Venus on the New Zealand Expedition in 1874, when he took 237 photographs, and observations at the Solar Eclipse of 1869, at Des Moines, Iowa.

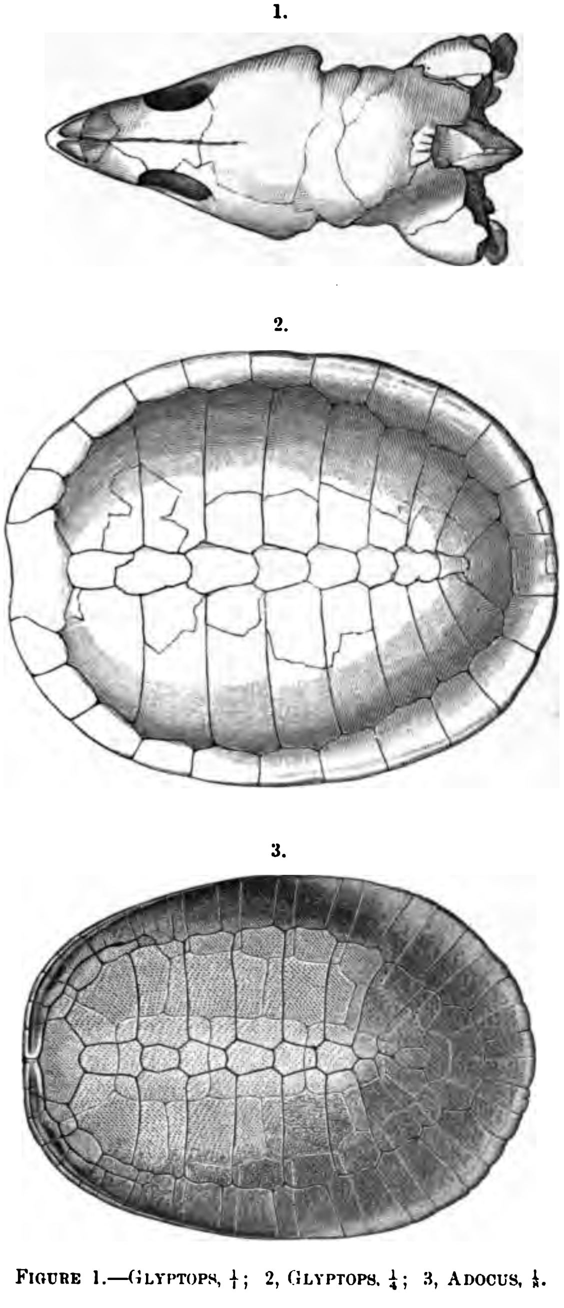
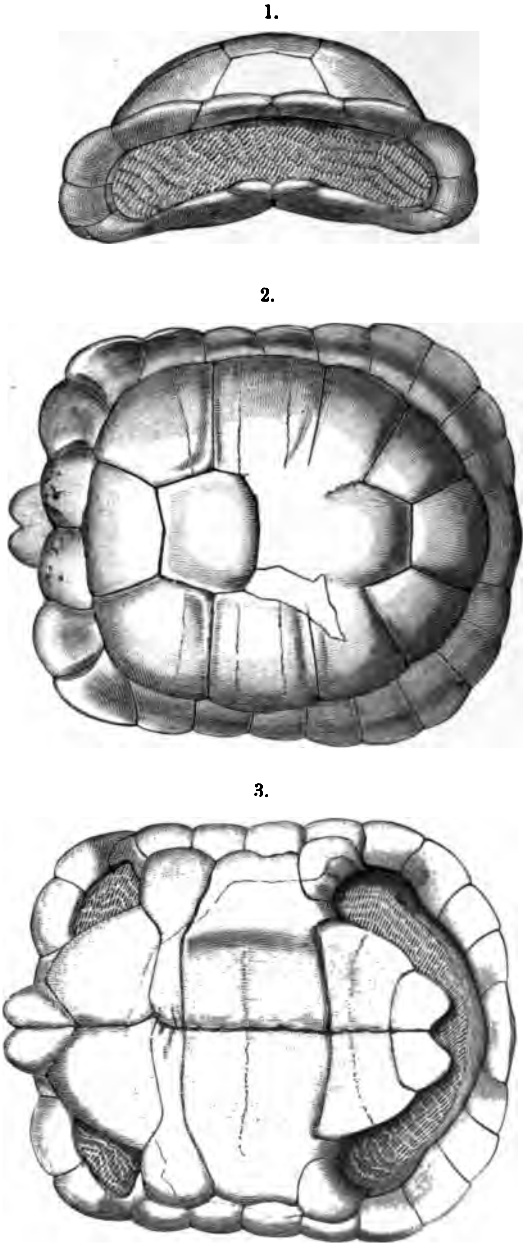


FIGURE 1.—GLYPTOPS, $\frac{1}{1}$; 2, GLYPTOPS, $\frac{1}{4}$; 3, ADOCUS, $\frac{1}{8}$.



TESTUDO BRONTOPS, Marsh, $\frac{1}{12}$.

APPENDIX.

T. XXI.—*Notice of some Extinct Testudinata;* by O. C. MARSH. (With Plates VII and VIII.)

E remains of various Testudinata, some of special inter iave recently been examined by the writer. A brief iption of a few of these is given below, and this, with the s on the accompanying plates, will make known their characters. Descriptions of other important specimens same group will be given in later communications.

Glyptops ornatus, gen. et sp. nov.

present genus is represented by a number of charac- c remains, among the most interesting of which is the shown on Plate VII, figure 1, which may be considered pe specimen. A striking feature of this skull is that its external surface is elaborately sculptured. This charac- itherto unknown in the *Testudinata*, has suggested the proposed.

its general features, this skull resembles that of *Chelydra ıtina*, Lin. It is wedge-shaped in form, when seen from , as shown in figure 1. The orbits are small, and well in The nasal opening is directed upward, rather than for- The premaxillaries project downward in front into a like beak. The nasals appear to be distinct. The max- s are deeply grooved below, but show no indications of eeth. The skull is roofed over posteriorly, as in Chelone, me other sea-turtles.

Portions of two other skulls beside the type specimen are preserved, and these afford several additional characters. They belong apparently to the same species.

There is a post-temporal arch. The occipital condyle is nearly round, and has a deep pit in the center. The condyle is formed entirely of the basioccipital, as the thin exoccipital plates do not reach the articular surface. The basioccipital processes are prominent, and directed backward. The pterygoids separate the quadrates and the basisphenoid. At their union with each other, they are much constricted, but expand in front. The quadrate is stout and curved, and its articular face is deeply notched.

The lower jaws referred to this species are slender and much less sculptured than the skull. The dentary bones unite at the symphysis by a short, open suture, and form a sharp elevated point to meet the decurved tooth-like beak above. The upper border is quite sharp, and fits well into the deep alveolar sulcus of the maxillary.

The carapace, represented in Plate VII, figure 2, was not found with the skull, and may possibly represent a distinct form. It resembles the corresponding part in *Dermatemys*, but the costals do not meet on the median line. It has the complete number of eight neurals, and in this and some other characters resembles *Helochelys*, von Meyer, from the Cretaceous Greensand of Germany, and *Pleurosternon*, of Owen, from the English Purbeck.

The plastron of a third individual had mesoplastral bones, an intergular plate, and inframarginals, as in the above genera. The pelvis was not coössified with the carapace or plastron The sculpture of both carapace and plastron is similar to that of the skull.

The present genus appears to be most nearly related to *Compsemys* of Leidy, from the Cretaceous, but as the skull of that genus is not known their more exact relations cannot at present be determined.

The specimens here described are from the Atlantosaurus beds of the Upper Jurassic of Wyoming, and hence are among the oldest known American turtles. They appear to represent a distinct family which may be called the *Glyptopsidæ*.

Adocus punctatus, sp. nov.

The type specimen of this species is in part represented on Plate VII, figure 3. The plastron belonging with the carapace shown is also in excellent preservation. The skull is not known. The structure of the carapace indicates that this specimen is nearly related to that described by Leidy, under the name *Emys beatus*,* but the present form may be distinguished by the deep distinct pits which mark the whole external surface.

The plastron shows evidence of an intergular plate, and inframarginals. There is no mesoplastron.

The nearest living form is probably *Dermatemys*, from Central America.

The present specimen is from the Cretaceous of New Jersey.

Testudo brontops, sp. nov.

The present species includes the largest American tortoises known, living or extinct. The type specimen, represented on Plate VIII, one-twelfth natural size, is not more than one-half as large as some seen by the writer in the Miocene of Dakota, near the base of the Brontotherium beds. They were surpassed in size only by the gigantic forms from the Pliocene of India.

The present species is very nearly related to the recent *Testudo elephantopus*, Harlan, from the Galapagos islands, and to the huge forms from Madagascar. It differs from the former in the presence of a nuchal plate, and from both, in the long median suture between the first marginal plates. The anterior portion of the plastron, moreover, projects considerably in front of the carapace. Other distinctive features are shown in the figures.

The specimen here described was secured by Mr. J. B. Hatcher, from the lower Miocene of Dakota.

New Haven, Conn., July 18th, 1890.

EXPLANATIONS OF PLATES.

PLATE VII.

FIGURE 1.—Skull *Glyptops ornatus*, Marsh; top view; natural size.

FIGURE 2.—Carapace of same species; top view; one-fourth natural size.

FIGURE 3.—Carapace of *Adocus punctatus*, Marsh; top view; one-eighth natural size.

PLATE VIII.

FIGURE 1.—*Testudo brontops*, Marsh; front view.

FIGURE 2.—The same specimen; top view.

FIGURE 3.—The same; bottom view.

All the figures are one-twelfth natural size.

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* Cretaceous Reptiles, page 107, Plate XVIII, figure 1, 1865.

THE

MERICAN JOURNAL OF SCIENCE

[THIRD SERIES.]

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RT. XXII.—*Rocky Mountain Protaxis and the Post-Cretaceous Mountain-making along its course;* by J. D. DANA.

THE Rocky Mountain Protaxis, or Summit Archæan range—hich includes the Front Range of Colorado and Montana, ıd is continued in British America to the parallel of 52½°, ıd beyond this in some isolated areas—was described, in my oronto paper,* as having an eastward bend in Montana and 'yoming through more than 250 miles of latitude. It was ated that owing to this eastward shove of the grand line of ights, the United States have a *Rocky Summit* area of great eadth west of the protaxis, and that this summit area of the otaxis is continued into British America *east* of the axis. he latter was proved to be the true continuation of the for-er by references (1) to its having, in the main, the same rocks the same succession to the top of the Cretaceous, as is shown a colored geological map by the course of the western out-le of the green-colored Cretaceous areas, and (2) by the evi-nce that both areas participated alike, and together, in the ocky-summit upturning closing the Cretaceous period, this ing sustained by the observations of the Canadian geologists.

It was further remarked that, aligned with the Canadian or rthern part of the Archæan protaxis, there was, to the south, interrupted continuation, 10,000 to 12,000 feet high, for a ndred miles along the Wasatch Mountains; and that this nge, which King showed to be near the eastern limit of the eat Basin, was the true western limit of the "Rocky Sum-t" region.

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* Bull. Geol. Soc. of America, i, 36.

I return to the subject to illustrate further the characters of the Rocky Mountain protaxis and the results of post-Cretaceous mountain-making along it, deriving the facts presented from the U. S. Government Geological Survey and that of the Canadian Dominion.

1. *Comparative Features of the Eastern and Western Protaxes.*

1. *The bend in the Western Protaxis related in origin to that in the Eastern.*—In my paper on the Eastern Archæan axis, in the last volume of this Journal, I point out the fact that the Green Mountain protaxis had a landward bend opposite the southern extremity of the Archæan continental nucleus, the nucleal V; and, in a note to page 379, the great bend in the Rocky Mountain protaxis is referred to as similarly situated abreast of the termination of the V. This correspondence in the two suggests similarity of origin; and we can hardly doubt that the bends were there made because the V there terminates; that the lateral thrust landward in direction which outlined the V, and later determined the existence and position of the protaxis, encountered diminished resistance where the nucleus loses its emergence, and that it hence shoved the line of uplift farther inland.

As regards the eastern protaxis this origin of the bend is recognized in the first edition of my Geological Manual (1863, p. 737), where I say "The Azoic [Archæan] nucleus of North America, spreading southward, formed a peninsula in northern New York. Even this bend in the nucleus continues in the finished continent; for New England has the same outline. Its east and south outlines are but a repetition of the east and south coast-lines of the old Azoic peninsula. This exact copying of the nucleus by the growing continent proves, better than all other evidence, the grand fact that the progress has been through oscillating forces acting against the stable Azoic nucleus." The dependence of continental mountain-making on Archæan features was thus fully recognized.

Differences between the two protaxes.—The eastern or Green Mountain protaxis is essentially simple in its course, notwithstanding the bend; the western was made a divided chain in consequence of the bend. The eastern protaxis is the eastern or sea-ward limit of the geological formations of the Continental Interior from the close of the Lower Silurian onward. But the main branch of the western protaxis, south of the bend, that of the Front Range and its continuation southward to Mexico, is not the western or sea-ward limit of any of the geological formations, and even the Cretaceous, the last of the Mesozoic series, extends west to the Wasatch line. This Wasatch line may hence be well designated the western of two summit

anches of the protaxis. The Rocky Summit region, men-
ned above, is situated accordingly between two protaxial
anches, the Front Range branch and the Wasatch. Moreover,
e former, although much the higher and most complete, was
least stratigraphical significance. The Wasatch line reaches
height between 11,000 and 12,000 feet; but the most of it
under a cover of later rocks. The western ouline of the
retaceous areas shows its course, from the Wasatch range,
est of south, to the crossing of the parallel of 37° N. by the
eridian of 115° W.

The Mountain-making along the Rocky Mountain Protaxis at the close of the Cretaceous period.

1. *In British America.*—The results of the summit post
retaceous disturbance in British America for a few degrees
rth of the United States boundary have been studied and
scribed by Dr. G. M. Dawson and Mr. R. G. McConnell, and
e reported upon in the Canada Geological Reports for 1885
d 1886. According to the accounts, a north-south belt
venty to seventy-five miles wide, between the parallels of
° N. and 52° N., was shoved up into flexures and as dis-
aced blocks. The western boundary of the disturbed region
the protaxial Archæan mountains along the Columbia River;
e eastern reaches out some miles into the great central Creta-
ous area of the Continent. It comprises the region of grand
ountain scenery along the summit pass of the Canadian
acific Railway which is there called the Rocky Mountains.

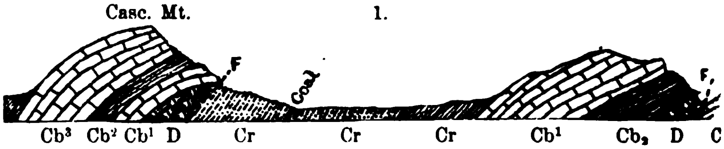
A transverse section along the parallel of 51° 15′, showing
e flexures and displacements, is described and figured by Mr.
cConnell. Through the western two-thirds of the range,
lts of Cambrian rocks, Lower and Upper Silurian, Devonian
d Carboniferous alternate, as a consequence of overthrust
xures and an occasional fault. In the eastern third—about
enty-five miles across—Cretaceous belts are comprised in the
ies, and the strata are partly in flexures but mostly in steep
onoclinal uplifts along seven upthrust faults, the thrusts all
land in direction of movement. One north-south Cretaceous
lt follows the course of the Cascade River Valley, or the
Cascade Trough."

The thickness of the Paleozoic formations in the region is,
cording to Mr. McConnell's estimates in the Bow and Wapta
alleys, about 29,000 feet; and to this the Cretaceous, to the
stward, adds 5000, making in all 34,000. Out of the 34,000
et of beds in the section at least a third is referred to the
mbrian, and more than half is included within the Cam-
ian and Lower Silurian series. The Upper Silurian and
evonian are relatively thin formations.

The rocks comprise, approximately, 10,000 feet of Lower Cambrian shales and quartzytes, in which have been found species of *Olenellus*, 7700 feet of dolomites, the lower part affording *Paradoxides* and the upper Lower Silurian fossils, 1500 feet of Lower Silurian graptolitic schists, 1300 feet of Upper Silurian limestone with *Halysites*, 1500 feet of Devonian limestone, 5100 feet of Carboniferous limestones and shales, probably Devonian below, and 5000 feet of Cretaceous beds anterior to the Laramie.

Figure 1 represents a portion of Mr. McConnell's section east of the Sawback Range crossing Cascade Trough. It represents the Carboniferous formation and Devonian shoved up, along a fault, over the Cretaceous of the Cascade Trough; while, to the eastward the Cretaceous rests conformably on the Devonian and Carboniferous; and then another great *upthrust* fault puts the Devonian above the Cambrian.

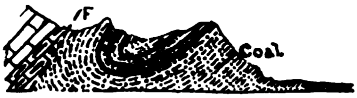
1.



Section across the Cascade Valley Cretaceous, with the Cascade Mountains on the west; Cb, Carboniferous; D, Devonian; C, Cambrian.

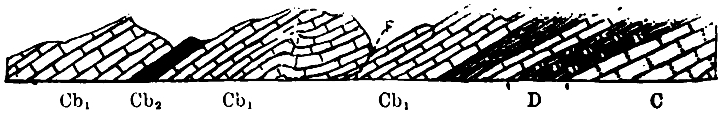
Figure 2 represents an overthrust synclinal in the Cretaceous beds of the Cascade Trough, 25 miles south of Mr. McConnell's main line of section, the whole breadth of which is about two miles. On the west side of the flexures, the Devonian and Carboniferous rise at a very steep angle; and they appear to have once stood as a great inclined anticlinal bending over the Cretaceous.

2.



Flexure in the Cretaceous of the Cascade Trough.

3.

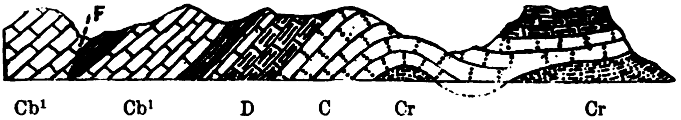


Section of mountains along Devil's Lake Valley, east of section in fig. 1.

In figure 3 a section is shown of the beds east of those of figure 1, along Devil's Lake Valley. The rocks of the whole

Paleozoic series are here shoved up so as to bring the Cambrian, C, into view. The Cambrian extends eastward in a broad anticline with the Devonian above, and is so continued to and over *the Cretaceous* of the foot-hills, as is seen in the following section, figure 4, taken a little to the south, on the South Fork of Ghost River. The actually observed overlap in this section made by the older beds amounts to nearly two miles. "The vertical displacement is over 15,000 feet, and the estimated horizontal displacement of the Cambrian beds is about seven miles in an easterly direction." The sinuous outcrop of the plane of junction, says Mr. McConnell, is exactly like the line of contact of two nearly horizontal formations. The overlying Cambrian stratum is bleached and cracked from the friction and "some enclosed argillaceous beds are converted into schists"—a fact not surprising since more than 15,000 feet of strata had a long move eastward in the overthrust. At one point, fossils of the Benton Cretaceous were found in the beds under the Cambrian limestone, while two miles north the latter limestone yielded Cambrian fossils, so that the demonstration of the overthrust was complete.

4.



Section across the Cascade Valley Cretaceous.

Mr. McConnell observes, in explanation, that in the Appalachian region, "the valley of East Tennessee presents an almost identical structure, and Professor J. M. Safford's interesting section across this valley might almost be taken for an illustration of the structure of this part of the Rocky Mountains." As in his section of fifty-two miles, with "eight great faults," and "no great flexures" crowded together, "the incipient folds split open longitudinally and the southeastern side of each heaved up, and over the northwestern," so it is essentially in the Rocky Mountain region described, except that the direction of up-thrust is reversed; and yet it is the same, since in each it is landward. West of the Sawback Range, between it and the valley of the Columbia, the facts are different in that "ordinary and overturned folds play the most important rôle. The greater part of the district has also been subjected to regional metamorphism, and all the beds except the purer limestones are in a more or less altered condition." The only fault indicated in the section is a down-throw fault.

These concordances, or rather identities, with Appalachian mountain structure are of the highest geological interest.

Dr. G. M. Dawson (in his Report on the portion of the Rocky Mountains between latitudes 49° and 51° 30′ in the Canadian Geological Report for 1885, part B) describes similar facts from the Cascade Trough, and the region just south between it and the parallel of 49° N. Through much of the distance there are two to three Paleozoic limestone ranges 6000 to 9000 feet in height, with intervening north-south Cretaceous belts, and the Cretaceous beds are upturned, along with the Paleozoic, through a belt 30 miles or more wide. As one of several similar facts, we cite: The "Misty Range [north of lat. 50° 30′ and east of long. 115°] is with little doubt a great compressed anticlinal of limestone *overturned eastward*." "The Cretaceous shales and sandstones pass beneath the limestones at an angle of about 40° and, to the east of them, are thrown into a series of overlapping folds." At the Crow Nest Pass (lat. 49° 35′), the Carboniferous beds are represented, in a section on his map, as having two steep eastwardly overthrust flexures against the area of Cretaceous rocks; and in another section, taken in the vicinity of the Kootanie Pass (lat. 49° 25′), the Cretaceous beds of the foot-hills, along the South Fork of Old Man River, are in a series of similarly overthrust flexures. Both up-thrust and down-throw faults are shown in the sections.

The Cambrian beds are described as closely resembling those of the Wasatch Mountains in lithological characters and rarity of fossils, and also, even more closely, those of the Colorado Cañon.

The thickness of the Cretaceous rocks of the Kootanie series (Lower Cretaceous) at the north Kootanie Pass (lat. 49° 25′ N.) is made about 7000 feet; and for the whole Cretaceous series in the mountain region, about 21,000 feet, while east of the disturbed region it is little over 8000 feet.

2. *In the United States.*—This upturned Rocky Mountain belt extends far northwestward along the summit; but how far has not yet been ascertained. Southward it is continued through Montana into western Wyoming, passing the eastward bend of the Archæan axis in lat. 45°-47° N. Sections of the rocks of the Wyoming Range, on the west side of the Green River Basin, and also of other ranges in the region, by Mr. A. C. Peale, published in the Hayden Expedition Report for 1877, are very similar to some of Mr. McConnell's in rocks, flexures and upthrust faulting, and in thrusts of Carboniferous beds from the west along a fault-plane to the top of the Cretaceous. The Cretaceous also is in flexures. The thickness of the Paleozoic and Mesozoic beds is made about 31,000 feet. Moreover, the sections from western Wyoming, in the Report of Mr. O. St. John, in the Hayden Report for 1878, are of

similar import as to flexures and as to the time of the disturbance.

Thus the great bend of the protaxis is passed by the Paleozoic and Cretaceous formations without essential change of characteristics either in kinds of rocks, or in their disturbed condition, or in time of disturbance.* It is of especial interest therefore to compare these regions with the mountain region farther south, that of the Wasatch and Uinta, very fully described, and mapped in colors, in the reports of the 40th Parallel.† In order that the facts and conclusions stated by Mr. King in his "Systematic Geology" may be the better understood, a copy of the map, but without the colors, is here given reduced from the large map of the Atlas (21×27 in.). But I would advise all readers to refer to the original map, if possible, as it is the grandest exhibition of facts pertaining to an individual case of mountain-making in all geological literature.

The following facts are from Mr. King's description of the region.

1. *Rocks.*—The series of rocks above the Archæan involved in the post-Cretaceous upturning included 13,000 feet of *Cambrian* (consisting of quartzyte 12,000 feet, with shales and siliceous schists and containing fossils above the quartzyte; 1000 feet of *Silurian* (the Ute limestone); 2400 feet of *Devonian* (including 1000 to 1500 feet of Ogden quartzyte, and the lower 1600 feet of the 7000 of Wasatch limestone); *Carboniferous series* (comprising (1) the remaining 5400 feet of the Wasatch limestone, (2) 5000 to 6000 feet of Weber quartzyte or Middle Carboniferous, (3) 2000 feet of Upper Coal-measure limestone, and (4) 650 feet of Permian); making in all about 30,000 feet of conformable Paleozoic beds. Above this series follow conformably, 1000 to 1200 feet of Triassic beds, 1600 to 1800 of Jurassic, and just eastward, in the Green River basins, the Cretaceous series 11,000 to 13,000 feet thick comprising (1) the Dakota beds 500 feet, (2) the Colorado beds 1000 feet (including Fort Benton, Niobrara and Fort Pierre groups of Meek and Hayden), (3) the Fox Hill beds 3000 to 4000 feet, and (4) the Laramie beds 5000 feet.

Explanations of the map.—A portion of Great Salt Lake lies on the western border of the map and Utah Lake on the southern, within a valley of Quaternary deposits (lettered Q), which has a height above tide-level of 4200 to 4600 feet. The Union Pacific R. R. crosses the country from near Evanston on the east to Uinta, Ogden and Corinne, and the Denver & Rio Grande R. R. goes southward from Ogden, by Salt Lake City to Provo and beyond. The Wasatch Mountains range from north to south east of the sites of Ogden, Salt Lake City and Provo, rise to a height for the most part of 10,000 to 12,000 feet, and have an abrupt front to the westward, the declivity on this side occupying a width of but one to two miles. The Uinta Mountains, an east-west plateau-like range, lie east of the southern half of the Wasatch. They have a broad slightly arched back of Carboniferous rocks, mostly 10,000 to 13,000 feet above tide-level. But only a fourth of the long range comes within the limits of the map. As is observed on the map, the Uinta and Wasatch Mountains are connected by a broad neck, mostly under igneous rocks (lettered *f*, initial of fire) about 8000 feet in elevation. The Oquirrh Mountains, a short range having Carboniferous rocks at summit, occupy the southwest corner of the map and reach a height to the south (in Lewiston Peak) of 10,623 feet. The large open area on the map east of the Wasatch Mountains, and north of the Uinta plateau, lettered W, and mostly 5000 to 7000 feet in height, is that of the Wasatch Eocene Tertiary, a southward extension properly of the Green River Eocene region of Wyoming; and another similar area south of the Uinta Mountains, lettered U, 9000 to 10,200 feet in elevation, is the Uinta Eocene basin. On the east-middle margin of the map, there is a small piece of the Bridger Eocene basin outlined and lettered B.

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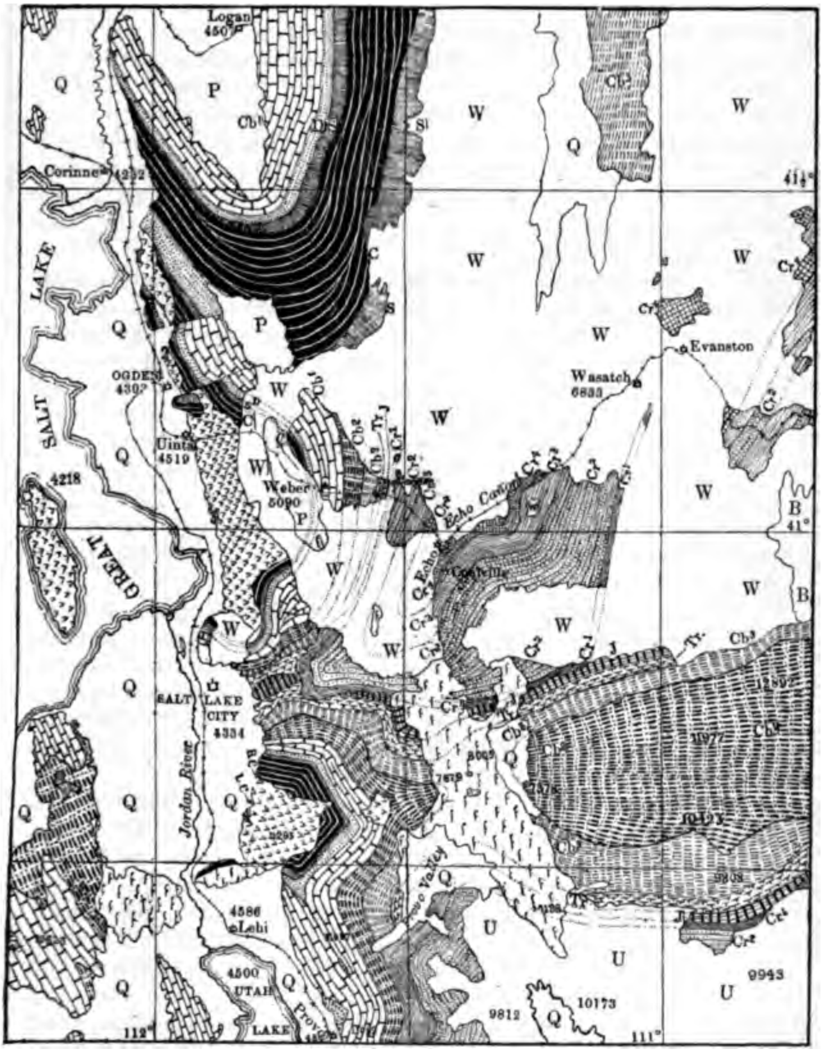
* The only prominent difference in the rocks is the absence or non-recognition in the British America sections of the Triassic and Jurassic.

† Geological Exploration of the 40th Parallel. under Clarence King: vol. i, Systematic Geology by Clarence King, 804 pp. 4to, 1878, with many maps and plates; vol. ii, Descriptive Geology, by Arnold Hague and S. F. Emmons, 890 pp., 4to, 1877, with 26 maps and many plates.

Besides the large Quaternary area, lettered Q, of the Salt Lake region, there are two others in the Uinta Eocene basin; another similarly lettered on the neck between the Uinta and Wasatch Mountains; and another to the north by the side of a Carboniferous area that extends north to the foot of Bear Lake.

In the northwest quarter of the map there is another Tertiary basin lettered P, which is referred to the Pliocene Tertiary; and just south, a second similar basin, in Ogden Valley, "a depressed area walled in by high mountains." A small area of Quaternary on the northwest corner of the neck between the Wasatch and the Uinta is omitted.

The streams of the region having cañons of geological significance (but with one exception not marked on the small map) are: *Jordan River*, connecting Utah Lake and Great Salt Lake; *Provo River*, entering Utah Lake near Provo and flowing through Provo Valley from the western Uinta slopes; *Little Cottonwood*, which flows westward and reaches the western base of the Wasatch Mountains at L. C.; *Big Cottonwood*, just north of the last, at B. C.; *Weber River*, which rises on the northwestern slopes of the Uinta Mountains and follows the railroad from Echo to Ogden and reaches the lake west of Ogden; the *Ogden River*, which drains Ogden Valley, and flows through a cañon on its way to Salt Lake.



Map of the Wasatch Mountains and adjoining part of Utah.

Reduced from the large colored Plate of the Atlas of the Fortieth Parallel Survey under Clarence King.

The style of marking for the several formations will be learned by following the series of areas along the railroad southeastward from above Weber to *Echo Cañon* and thence to the Uinta Mountains: the *Cambrian* C, black with fine white lines; *Silurian* S, finely cross-lined (always adjoining the Cambrian); *Devonian* D, dotted; Carboniferous Cb^1, Cb^2, Cb^3, corresponding to the divisions mentioned above except that the Permian is included in Cb^3; *Triassic* Tr, marked by Ts; *Jurassic* J, finely lined, and crossed by heavy lines; Cretaceous, Cr^1, Cr^2, Cr^3, Cr^4, corresponding to the subdivisions of the Cretaceous above stated, the last, which is the Laramie, being finely cross-lined.

The Archæan areas are marked with small Vs; and regions of trachytic eruptions, by the letter *f* as stated above.

The only liberty taken with the original map by the writer is the insertion of dotted lines to indicate the continuations between the disjoined parts of areas. These on the neck between the Uinta and Wasatch Mountains are indicated by the section at the bottom of the original map as well as by the outcropping areas within the neck; and the others are plain followings of the map and the text, except for the Lower Cretaceous area north of the northwest part of the Uinta Mountains. If regarded as doubtful beyond this, they are to be taken as the writer's suggestions.

We come now to the orographic facts. 1. Along the western wall and summit of the Wasatch, the larger Archæan areas are numbered 1, 2, 3, 4; 1 is the most northern; 2 is east of Ogden; 3 commences abreast of Uinta and continues for about 25 miles; 4 has its summit in Lone Peak, 11,295 feet in height. Just east of the last there is the isolated Clayton Peak (marked by Vs on the map) 11,889 feet high.

The Wasatch Mountains commence to rise on the north, abreast of a broad synclinal of Paleozoic rocks from Cambrian to Carboniferous, the east part of which is a continuation of the Bear Lake Range, 9,000 to 10,000 feet in height. Other isolated Archæan ridges occur north of and within Salt Lake.

The general dip of the Paleozoic formations in the mountains is eastward from 60° to 25°. The line of *strike* of the outcrops is peculiar in having large in-and-out bends along the range, as is easily seen by following the black-lined areas of the Cambrian; there is a bend eastward to the Weber region, and then a profound bend westward through the gap nearly 18 miles wide between the Archæan ridges 3 and 4, abreast of Salt Lake City, making a synclinal in the squeeze through the gap, whose broken-off head overhangs and confronts the Salt Lake Valley; then another eastward sweep of more than a semi-circle around "Lone Peak" first the Cambrian and then

n, Devonian and Carboniferous belts, all which keep
es and widths, with southeastward and northeast-
of 45°, heeding but little Clayton Peak. Thus, as
ows, the formations under the mountain-making pres-
zig-zagged about and among the Archæan heights.
ward bend abreast of Weber is deeper on the map
he actual bend, because of the erosion along the
part of the range which has there sunk the surface
90 feet. But the *westward* bend abreast of Salt
must have projected its head much farther eastward
nap represents; any attempt to complete the curves
s makes this evident. The dip of the beds in the
l its center from the north and south is 50° to 60°.
also shows that in the range south of the Lone
æan area, the Lower Carboniferous (Cb^1) is doubled
n an anticline having the strike of the mountains—
shown by the Devonian line along its center.
s of the strata and general facts are given on the
Geological Map between pages 760 and 761 of Mr.
port.
ormous amount of warping undergone by the *Ju-*
Cretaceous beds to the eastward is partly indicated
rses of the outcrops. From the Cambrian outcrop
r to Echo Cañon, the succession of formations on
cludes the whole conformable series from the Cam-
o the Laramie (Cr^4); and from Echo southeastward,
reverse of the series, passing from the Laramie group
ugh the successive members in the series to the top
ta Range, as King states on page 586, where are
f the Middle Carboniferous (Cb^2). The dip is east-
45°, 75° to 70° at Cr^1, and then 20° at Cr^4 where it
l to northwestward in a syncline, and so continues
mit where it is 4° to 5°. Consequently the warping
a syncline at Echo Station.
ks of the Uinta plateau were therefore involved in
n of warping which eventuated in forming the
ountains. All the isolated areas of the Cretaceous
the Wasatch basin also show the warping; that of
ie near Evanston having eastward dips of 25° and
hat south of Evanston being an anticline with dips
er side of Cr^2; and that east of Evanston, the con-
of the anticline with dips of 60°. The small area
ous (Cr^1) south of Wasatch has dips of 80° west-
ward, the direction corresponding with that of the
outh.
mit beds of the Uinta plateau dip slightly north-
southward, and near the east margin of the map it

has the great height of 12,892 feet.* The Wasatch range is lower than the Uinta, but also steeper and narrower, and in the making it was far more roughly wrenched and broken, and hence must have lost much more by erosion.

The great area of trachyte (35x9 miles) over the interval between the Uinta and Wasatch Mountains and the two small areas on the same northwest line in the low Eocene area, the last just south of Weber, indicate that "the entire length of this trachytic vent was about fifty miles." This outflow is described as an effect of the mountain-making movements—a faulting according to King.

One of the great results of the 40th Parallel Survey brought out by Mr. King is the establishing of the fact that the Great Basin, between a line near the Great Salt Lake and the meridian of 117½°, was raised above the sea-level at the close of the Carboniferous, or simultaneously with the making of the Appalachian Mts., it being proved that the Carboniferous rocks were the latest marine formation. The Oquirrh Mountains were part of the eastern margin of this Mesozoic dry land. No Triassic, Jurassic, or Cretaceous beds are reported from the eastern base of the Oquirrh or the western of the Wasatch in any part of the Salt Lake region, or over the region west until the meridian of 117½° W. is passed.

In discussing the origin of the Wasatch, Mr. King states the principle, gathered from his observations, that in case of each great mountain-making flexure, wherever an Archæan mountain range existed beneath accumulated sediments, there a fold had taken place. He observes that "in the case of the Wasatch, it is seen from the relations of the old Archæan underlying range, that this enormous mountain body determined the existence and character of the post-Cretaceous fold." He immediately adds: "In the case of the Uinta, it is impossible to say how far underlying Archæan rocks played a part. The single limited outcrop of pre-Cambrian rocks at Red Creek (in its northeastern side) is certainly at the most ruptured and actively dislocated point of the whole Uinta Range." Mr. King, although not adopting the contraction theory of mountain-making to its full extent, still gives to tangential compression a prominent place in the process. He observes (on page 752) that when a tilting of strata against an Archæan ridge has taken place "it is evident that the interval of Archæan rock must have been compressed, and in yielding to this force the Archæan bodies have developed an amount of plasticity which, in view of their crystalline nature, is very surprising."

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* This high region is continued eastward, and in the next quarter of the range there are, among the heights, Gilbert Peak, 13,687 feet, and Emmons Peak, 13,694 feet, each near the meridian of 110° 20′ W.

ıdering the extent and character of the displacements, horizontal overthrusts, in the Canadian portion of the Mountains described by McConnell, the conclusion that ial thrust has acted likewise in the case of the Wasatch to be reasonable, although the results are in important lifferent. And it can not be questioned that the force could compress and reduce to plasticity a resisting ın mass might make great movements of Paleozoic ver an Archæan surface, inclined or not, and probably ısticity where movement was effectually resisted.

facts in the Wasatch and Uintah region come therefore rmony with others in the Rocky Mountain region, and ıto near likeness to those from the Appalachians. The ent manifested was either "a thrust upward and east- the whole Archæan body when the Paleozoic flexures ace" (p. 48 of Mr. King's Report), or its compression sion (p. 752), or else, as another might suggest, a thrust rd of the sedimentary strata against the Archæan range. orphic action in the overlying limestones about Clayton's mentioned on page 45 as a "mechanical" result during vements.

ıe preceding explanations, the reported facts are made their own story. For some inferences from them con- in the report of Mr. King I am unable to find a suffi- asis in the facts. Among these I question the follow- ıat a full section of the Mesozoic and Paleozoic series, feet, more or less, then existed in the region of Salt Valley, as a westward continuation of like beds capping asatch Mountains; that along a fault-plane following the axis of the Wasatch Archæan and of its "capping sediments," the western mass dropped down to depths g the thickness of the beds. It does not seem certain y *great* fault along this line was among the results of t-Cretaceous orographic disturbance.

reason for doubting is, first, the absence of direct evi- for no outcrops of Mesozoic beds in the Salt Lake are reported, and no proof of their presence there as deposits is mentioned or has since been observed, h deep borings have been made. Again the Oquirrh ıins and Wasatch Range are but twenty miles apart, and milar Carboniferous rocks at summit at nearly the same and without other sustaining facts it is hard to believe the narrow space between such an enormous downthrow rial ever took place.

ing stated is adverse to the view that at the post- iferous disturbance, the Wasatch Range (not a line west long Salt Lake as the Report suggests) became the eastern margin of the emerged Great Basin, that is, the coast region of the eastern Mesozoic seas, in which the Triassic, Jurassic and Cretaceous rocks were formed; and if so, the Wasatch Archæan was not within the subsiding area over which Mesozoic sediments were laid down, but part of the more stable outside region, like the Archæan protaxis north of the United States boundary.

While regarding with admiration the survey of the Fortieth Parallel, and adopting many of the conclusions presented in its Reports, it seems reasonable to hesitate here, so far at least as to pass in review the bearings on the geological history of the region of this modification of its views; and I therefore proceed to state the sequence of events which appears to be indicated by the reported facts.

1. At or near the close of the Paleozoic, when the area of the Great Basin lying to the east of the meridian of 117½° W. emerged, placing its latest Carboniferous rocks more or less, perhaps but little, above tide-level, the Wasatch was a low Archæan range making part of the *eastern limit* of the Basin.

2. In the shallow seas to the eastward, and beyond longitude 117½° W. westward, as explained by King, subsidence was still continued; and over the bottom, made of Carboniferous and other older rocks (the Carboniferous of the Uinta area included), Triassic and Jurassic beds were laid down. Afterward on the east, Cretaceous deposition went forward over the same area (but with probably somewhat contracted limits), the subsidence still going on.

3. The Triassic and Jurassic formations, compared with those of other regions, are thin, and hence no unusual source of sediment was needed for their accumulation and no great height in the bordering lands; but by the time the Cretaceous period began, or during a post-Jurassic disturbance,* the dry land had probably become more emerged and had received some permanent additions.

4. During the post-Cretaceous epoch of disturbance, the sedimentary formations to the top of the Laramie were thrust westward against the stable Archæan rocks of the Wasatch Range, shoved up the Archæan slopes, forced into tortuous flexures among the Archæan peaks, and doubled up as they were pushed through the gap. How much of the flexed formations passed the summits cataclysmically into the Salt Lake area of the time has passed out of record through denudation.

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* I refer for facts with regard to such a disturbance to the important paper of Mr. S. F. Emmons in the First volume of the Bulletin of the Geological Society of America, "On Orographic Movements in the Rocky Mountains," p. 245.

This move of the accumulated formations from the Cam-
n to the Laramie, in the latitudes of the Wasatch, was part
a general movement that extended through a length of
miles or more from north to south, it including the mak-
of the mountain flexures and faults in Canada described
Mr. McConnell, and how much farther north, we do not
know.

If the uplifts were anywhere produced through lateral or
ential thrust, the tangential movement was general. It
thrust from west to east and the reverse, producing sur-
movements according to resisting conditions, the oro-
hic results being greatest where, as Mr. King states,
hæan ranges resisted the movement and so localized its
ts.

he above inferences appear to be warranted by the facts at
ent known.

And so the Wasatch Range was essentially finished;
ningly an individual mountain range, but really polygenetic;
a lofty ridge of Archæan make; then enlarged by Paleo-
additions and changed in level by increased emergence, but
out so far as known, any upturning of the beds; finally
r further preparation by sea-border depositions through all
ozoic time, profound movements completing the process
development, and that also of other ranges both of the
ate and plateau kinds, the Uinta among the latter.

The new ranges and others older, then became the rela-
ly stable confines of Eocene lake-basins in the enclosed
ky Summit region of the United States, the Green River
n, the Wasatch, the Uinta and others, over which subsi-
ce and deposition were still continued.

n the preceding observations on mountain-making along the
ky Mountain protaxis, I have referred, so far as the territory
he United States is concerned, only to the *western* branch
he protaxis, or that including the Wasatch Range. The
ern branch, or that of the lofty Front or Colorado Range,
resisted the tangential thrust, like the Wasatch to the
t; but the disturbance resulted only in making out of the
taceous and inferior rocks on the east, little foot hills, 500
500 feet in elevation over a breadth of 10 to 15 miles.

n excellent account of the flexures and faults in these hills,
strated by many transverse sections besides maps and views,
ublished in the volume for 1873 of the Hayden Expedition
orts, by Archibald R. Marvine, an accurate observer whose
y death was a serious loss to American Science. The sec-
s described are from the eastern base of the mountains for
e distance north of Denver, between the parallels of 40°

15′ and 40° 30′. The sections, as exhibited on the plate accompanying the article, indicate that the uplifting force, besides flexing the beds, made a series of faults in the formations, and that these faults were upthrust faults of blocks that included the Archæan with the overlying rocks; that the upthrust was in general westward. The disturbed region shades off eastward into the horizontal strata of the great plains. For descriptions of the beds, and of the *echelon* character of the flexures (a feature first mentioned, the author says, by Hayden in his report of 1869) reference may be made to Mr. Marvine's report. The volumes of the survey of the 40th Parallel contain other facts on the subject, which are discussed by Mr. King.

The observations prove that although the Front Range, or the eastern branch of the Protaxis, greatly exceeds in height the western, the uplifts adjoining it were very small. This high Front Range *stands within the wide area of Mesozoic deposition, within the area therefore of Mesozoic subsidence;* while the line of the Wasatch and the protaxis in British America is to the west of this area and outside of it; and this may be a reason for the feeble orographic effects at its base.

ART. XXIII.—*The Magneto-optical Generation of Electricity;* by SAMUEL SHELDON, Ph.D.

WHILE experimenting upon the effects of alternating currents of electricity upon the plane of polarized light, results were obtained which made it feasible to try a series of experiments, in which the Faraday arrangements were reversed. Although the series is incomplete, yet the little that has been accomplished seems worthy of publication.

It is well known* that if a beam of plane polarized light be passed through a tube containing bisulphide of carbon, and if the tube and beam lie in the direction of the lines of force of an electromagnet about to be excited, the plane of the emergent beam will be rotated upon exciting the magnet. The direction of rotation will be the same as that of the exciting current and the amount of rotation will depend upon the strength of the current. If the current be reversed the plane will be rotated in an opposite direction and by exactly the same amount. Thus the rapidly alternating current would produce a rapid swinging to and fro of the plane of light.

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* Faraday, Exp. Res. 2146, vol. iii, p. 1.

Now if a difference of potential, under these conditions, produces such a rotation of the plane, why should not a rapid rotation of the plane under exactly the same conditions produce an inverse difference of potential between the terminals of the coil? A continuous rotation should produce a continuous current of electricity and an oscillating of the plane an alternating current. The experiments which have been performed verify the latter supposition.

The coil employed was wound upon a thin brass tube as a core. This was closed at each end by plates of glass and was provided with holes for filling with carbon bisulphide. Its length was 175^{mm} and its diameter 23^{mm}. Upon this was wound the coil from double silk-covered copper wire of $0{\cdot}85^{mm}$ diameter. When wound the length of the coil was 150^{mm} and its diameter 45^{mm}. The resistance was 7·21 ohms.

A quantitative measurement of the Faraday effect was first made and in the following manner: A beam of light from an incandescent lamp, after passing through a large nicol, was made to traverse the bisulphide of carbon in the coil. Upon emerging the beam was brought to extinction by the proper adjustment of an analyzing nicol. A measured current of electricity was now passed around the coil. This necessitated a readjustment and rotation of the analyzing nicol to reproduce extinction of the beam. Within the limits tried this rotation was proportional to the current strength. As a mean of many measurements it was found that a current of 1 ampere required a rotation of 78 minutes of the analyzer. Accordingly 278 amperes would be required to rotate the plane through 360°, providing the proportionality between current strength and rotation remained unaltered.

Now, if we consider a plane polarized ray of light to be made up of two opposite circularly polarized rays, then a particle of ether in the bisulphide of carbon describes a simple harmonic oscillation in a plane. This motion in a straight line is the resultant of the two oppositely directed, equiperiodic, circular rotations of equal amplitude. If now a magnetic field be created, the particle undergoes an instantaneous circular electric displacement which results in the retardation of one and the acceleration of the other component rotation. The line of oscillation suffers rotation as a result, and assumes a new position. The displacement must be instantaneous, for, were it continuous, the line of oscillation would continue to rotate and the analyzer could not be made to produce extinction. If now, instead of allowing the magnetic field to produce this circular displacement, we superimpose, by mechanical means, a third rotation upon the two existing components, then a magnetic field should result and an electromotive force be induced in a coil surrounding that field. Such a result would be obtained by rotating the polarizing nicol. The rapidity of rotation must be very great, and, if it requires 278 amperes (an impressed electromotive force of 2000 volts) to rotate the plane through 360°, then to produce this electromotive force the polarizer must be revolved with a frequency of the same order as of the oscillations of light. But a nicol cannot be revolved much above 200 times per second. The centrifugal force resulting from a higher rate will, owing to the strain produced, interfere with the performance of its functions as a polarizer. This rate of 200 revolutions per second would produce, in the apparatus employed, an electromotive force of perhaps 0,000000001 volts, giving a current too small to be detected by any galvanometer in my laboratory. Hence use was made of the extreme delicacy of the telephone as a substitute, and a swinging of the plane instead of a revolution.

The arrangement of apparatus was as follows: Light from an arc lamp, after passing through a large nicol, was reflected, at a very obtuse angle, from a small movable mirror and then passed through the bisulphide of carbon in the coil before mentioned. The two terminals of the coil were carried to a room three stories below and in another part of the building. Here they were connected through a telephone and a switch. The mirror (10×30^{mm}) was fixed in a brass frame free to rotate about an axis nearly parallel with the ray of light. This frame was connected by an eccentric and gears to the main shaft in the work shop. By this arrangement the mirror was made to oscillate through 45° about 300 times each second. The plane of polarization was thus twisted through twice that amount, or 90°, in the same time. While this oscillation was going on in the workshop, an ear placed at the telephone at the other end of the circuit could easily distinguish a tone, which, however, was the octave above that made by the moving mirror. When the circuit was broken the sound ceased to be heard, but upon again closing the tone became audible. With a rate of 200 oscillations per second the note was not so easily distinguished. But upon closing the circuit that peculiar sizzling noise so common in telephone circuits was heard.

During the experiments the mirror was frequently broken by the high rate of vibration. But another was quickly substituted by my assistant, Mr. Baker, whom I have to thank for this and the construction and management of the rotating apparatus.

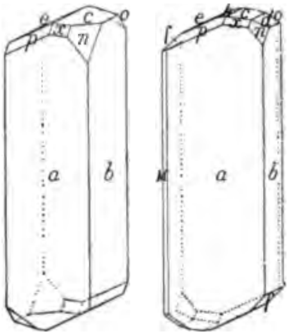
Polytechnic Institute of Brooklyn,
June, 1890.

XXIV.—*Contributions to Mineralogy,* No. 49; by F. A. ENTH, *with Crystallographic Notes,* by S. L. PENFIELD.

the following paper we give the results of the examina- of some superior specimens of the very interesting ferric iates from Mina de la Compania near Sierra Gorda in the ince of Tocapilla, about 125 miles interior from Antofa- , Chili. They were recently brought from this locality rof. Henry A. Ward, and are now in the cabinet of Mr. ɜuce S. Bement of Philadelphia, who very kindly placed in our hands for investigation.

1. *Amarantite.* A. Frenzel.*

ıe crystallization is triclinic, confirming the determination ɜ by optical tests on cleavage fragments by E. A. Wülfing.† habit of the crystals, many of which are doubly termi- l, is slender prismatic, the vertical zone being composed ɜipally of the pinacoids *a* and *b*, ɘ the ends are modified by a ber of brilliant faces. Individ- rystals are frequently 10^{mm} long 1^{mm} in diameter; some of them a nearly square cross section, fig. hers are flattened parallel to the coid *a*, fig. 2. The forms ob- ɜd are,



00, *i*-ī	*d*, 011, 1-ĭ′	*x*, 101, —1-ī
010, *i*-ĭ	*e*, $0\bar{1}1$, 1-ĭ	*p*, $1\bar{1}1$, —1
001, *O*	*f*, $0\bar{2}1$, 2-ĭ	*o*, $\bar{1}11$, 1′
$1\bar{1}0$, *I*	*h*, $0\bar{1}2$, ½-ĭ	*n*, 121, —2-2̆′.

he following measurements were chosen as fundamental:

$c \wedge a$,	$001 \wedge 100$	88° 53′	$a \wedge p$,	$100 \wedge 1\bar{1}1$	57° 48′
$c \wedge b$,	$001 \wedge 010$	84° 16′	$a \wedge e$,	$100 \wedge 0\bar{1}1$	92° 48′
$c \wedge e$,	$001 \wedge 0\bar{1}1$	31° 25′			

ı which the following relations are calculated:

$$\alpha = 95^\circ\ 38'\ 16'' \qquad \beta = 90^\circ\ 23'\ 42'' \qquad \gamma = 97^\circ\ 13'\ 4''$$

$$\breve{a} : \bar{b} : \dot{c} = 0{\cdot}76915 : 1 : 0{\cdot}57383$$

ı addition to the above the following are some of the im- ant measurements which were made:

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* Tschermak's Mittheilungen, ix, p. 398, 1888.

† Tschermak's Mittheilungen, ix, p. 402, 1888.

		Measured.	Calculated.
$c \wedge M$,	$001 \wedge 1\bar{1}0$	92° 31′	92° 48′
$c \wedge p$,	$001 \wedge 1\bar{1}1$	42° 45′	42° 46′
$c \wedge o$,	$001 \wedge \bar{1}11$	40° 15′	40° 18′
$b \wedge p$,	$0\bar{1}0 \wedge 1\bar{1}1$	72° 53′	73° 2′
$p \wedge x$,	$1\bar{1}1 \wedge 101$	25° 59′	26° 0′
$c \wedge x$,	$001 \wedge 101$	36° 26′	36° 25′
$x \wedge n$,	$101 \wedge 121$	38° 24′	38° 26′
$c \wedge d$,	$001 \wedge 011$	28° 32′	28° 33′
$c \wedge h$,	$001 \wedge 0\bar{1}2$	16° 25′	16° 30′
$c \wedge f$.	$001 \wedge 0\bar{2}1$	52° 27′	52° 28′
$a \wedge b$,	cleavage	82° 39′	82° 42′

The pinacoids *a* and *b* were vertically striated and in combination with vicinal faces so that no satisfactory measurements were made in the vertical zone. The faces at the ends of the crystals, although small, gave very good reflections of the signal, the result of which can be seen in the very satisfactory agreement in the above table between the measured and the calculated angles. The cleavage is very perfect parallel to the pinacoids *a*, 100 and *b*, 010. The mineral also occurs in radiating, bladed crystalline masses, with cleavage surfaces sometimes 35^{mm} long and $8–10^{mm}$ wide at the broadest portion. The angle between the two pinacoids *a* and *b*, 82° 39′ in the above table was obtained from this material, the reflection from both cleavages being very sharp and distinct. Wülfing gives for two faces in the prismatic zone (he does not state that they are cleavage) 81° 53′, 82° 11′, 82° 38′ and 83° 11′.

The color is a brownish red, amaranth-red. The optical properties agree closely with the determinations made by Wülfing.* Crystal or cleavage plates parallel to the pinacoid *a*, 100, show under the polarizing microscope a brownish red color, and very little action on parallel polarized light, but with convergent light an optical axis and a bisectrix can be seen, slightly removed from the center of the field, also part of the ring system of the other axis. The plane of the optic axes makes an angle of about 38° with the vertical axis, its trace on 100 being from right above to left below. The pleochroism is not very strong, the color being darker in the direction of the plane of the optical axes than at right angles to it. One of these cleavage plates was used in the axial angle apparatus, and although it was not at right angles to the acute bisectrix, it yielded a measurement of the apparent optic axial angle in air, which is very characteristic,

2E for yellow, Na flame, 63° 3′
2E for red, Li flame, 59° 3′

The section was practically opaque to the green light of a thallium flame. The strong dispersion of the optic axes $\rho < \nu$ is ceable. Sections parallel to the pinacoid *b*, 010, show er the microscope a strong action on polarized light, giving extinction at 16°–17° from the vertical axis in the acute e β above and behind. The pleochroism is very marked, vnish red parallel to the extinction direction 16° from the ical axis and pale lemon-yellow at right angles to this. In vergent polarized light this section yields no interference nomena. Hardness 2·5. Specific gravity 2·286.

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* Loc. cit.

marantite occurs associated with, and sometimes imbedded finely fibrous orange-colored mineral, probably sideronat, also small quantities of limonite and quartz. The mate- for analysis was selected from the best bladed masses; it ms to have been slightly contaminated with traces of ferric rate. The fine powder is gradually decomposed by cold er into a basic insoluble salt. The quartz was deducted from analysis, which is as follows:

	I.		II.	III.	Molecular ratio.		Calculated.
H_2O	----	at 110° 12·17	63·45	28·29	1·570	7	28·250
SO_3	35·46			----	0·443	2	35·875
Fe_2O_3	37·46		37·09	----	0·234	1·05	35·875
CaO	trace		0·09	----			
N_2O	0·59		----				
K_2O	0·11		----				

hese analyses give the formula: $Fe_2S_2O_9+7H_2O$. 3 molecules of water were lost at 110°.

or comparison I give the analyses of A. Frenzel (loc. cit.), B. Mackintosh (this Journ., III, xxxviii, 243), and L. Darky (Neues Jahrb. f. Min., 1890, i, 55).

	Frenzel.	Mackintosh.	Darapsky.	Calculated.
H_2O	27·62	[27·44]	28·33	28·26
SO_3	35·58	36·15	36·20	35·87
Fe_2O_3............	37·26	35·69	35·62	35·87
Al_2O_3		0·21		
Na_2O		0·51		

r. Mackintosh states that at 110° 3·48 molecules of water e expelled.

2. *Sideronatrite*, A. Raimondi.*

he material which we have examined consisted of masses, etimes 70–80^{mm} in thickness, of a fine fibrous mineral pale orange to straw-yellow color. The little splintery or natic crystals when examined with the microscope seem to n a cleavage face and show in polarized light an extinction llel to their longer axis. They show a slight pleochroism, straw-yellow for rays vibrating parallel to the longer axis, st colorless at right angle to this. In convergent polarized light the small splinters show indistinctly an obtuse bisectrix, the plane of the optic axes being parallel to the longer axis. The longer axis is, moreover, axis of least elasticity. These optical properties indicate orthorhombic symmetry while Raimondi regards the crystallization as probably monoclinic. Hardness= 1·5. Specific gravity 2·355.

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* Zeitschr. Kryst., vi, p. 633, 1882.

Associated with the sideronatrite and sometimes forming veins of about 10 to 20^{mm} in thickness is a grayish white laminated mineral, ferronatrite, which is also often intermixed through the whole mass of the sideronatrite, in minute white particles. If it had not been for the difference in the color of these two minerals it would have been impossible to obtain sideronatrite in a state of sufficient purity for analysis.

Decomposed by cold water into an insoluble basic ferric sulphate. The analyses gave:

	I.		II.	III.		IV.	V.	Raimondi's analysis after deducting 4·26 p. c. impurities.
H_2O at 110°	9·42 }	61·61	[17·05]	at 110° 9·47 }	61·34	[16·67]	17·77	16·02
SO_3			44·02			44 41		45·16
Fe_2O_3		21·63	22·54		21·24	21·66		22·55
CaO		not det'd	not det'd		not det'd			
Na_2O		16·32	16·39		15·91	16·94		16·27
		99·56	100·00		98·49	100·00		100·00

	Mean.	Molecular ratio.			Calculated.
H_2O	17·07	0·948	7	or 7	17·26
SO_3	44.22	0·533	3·92	4	43·84
Fe_2O_3	21·77	0·136	1	1	21·92
Na_2O	16·39	0·264	1·94	2	16·98

giving the formula: $2Na_2SO_4 . Fe_2S_2O_9+7H_2O$. At 110° loses about 4 molecules of water.

3. *Ferronatrite*, J. B. Mackintosh.*

This occurs in cleavage masses, white to grayish white in color. No distinct crystals were observed, but from the cleavage and optical properties the crystallization must be hexagonal. The cleavage is prismatic, perfect, the angle between cleavages measuring 60° 2′, 59° 58′ and 60° 5′ where the surfaces were quite perfect and the reflections sharp; a number of other angles were measured, all approximating to 60°. A section cut at right angles to the vertical axis showed in convergent polarized light the interference figure of a uniaxial mineral, and with a quarter undulation mica plate positive double refraction. A prism cut with its edge parallel to the vertical axis yielded with yellow light (soda flame) the following indices of refraction, $\omega = 1·558$, $\epsilon = 1·613$ indicating rather strong ve double refraction. Some of the original material, us by Mr. Mackintosh for comparison, appears to be ical with this in every respect except that it occurs in ting prismatic crystals reminding one of wavellite. Hard- = 2·5 Specific gravity = 2·547 and 2·578.

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* This Journal, III, xxxviii, p. 244, 1889.

e analyses of the purest mineral gave:

	I.	II.	III.	IV.	Mean.	Molecular ratio.	
$_2O$	62·96	63·58	11·62	12·15	11·89	0·66	6
O_3			51·27	51·33	51·30	0·64	6
e_2O_3	17·32	17·20	17·30	17·36	17·30	0·11	1
aO	0·22	not det'd.					
a_2O	19·63	20·01	20·15		19·95	0·32	3
$_2O$	0·16						
	100·29						

ing with the formula: $3Na_2SO_4 . Fe_2S_3O_{12}+6H_2O$.

	Calculated.		Mackintosh's analysis for comparison.
H_2O	11·56		11·34
SO_3	51·39		50·25
Fe_2O_3	17·13		17·23
Na_2O	19·92		18·34
		Al_2O_3	0·43
		SiO_2, etc. insoluble	2·00
			99·79

r. Mackintosh states that his mineral lost at 110° C. 5½ mole- of water. The material above analyzed when exposed in tate of a fine powder for two hours at 100° C. lost only per cent (0·72 gram lost 0·0020 grm.).

4. *Utahite.* ?

nong the minerals, collected by Messrs. Geo. L. English ., at the Mimbres Mine near Georgetown, New Mexico, very minute, microscopic brownish white, apparently gonal scales, which had the appearance of Utahite.

ey were mixed with a very large quantity of quartz, van- ite and descloizite. After the vanadates and other impur- were dissolved out by dilute nitric acid, the hexagonal s remained behind in a pretty pure state, but mixed with siderable quantity of quartz. The material thus obtained divided into two portions, weighing together 0·2792 grm. 1983 grm. gave 31·82 per cent quartz; deducting this, the by ignition in the other portion was 26·85 per cent and erric oxide, 55·10 per cent.

809 grm. gave 29·03 per cent quartz, and after deducting the balance gave 27·16 per cent of SO_3 and 56·49 per cent O_3

The loss by ignition is almost the same, as the amount of SO_3 found in the second portion, which seems to indicate that the mineral under consideration contains *no* water, but only sulphuric acid. The ratios of $SO_3 : Fe_2O_3$ would be

in the first portion, $0{\cdot}336 : 0{\cdot}344$ or $1 : 1$
in the second portion, $0{\cdot}339 : 0{\cdot}353$ or $1 : 1$

so that the composition of the iron sulphate would be

$$Fe_2O_3 . SO_3 \text{ or } Fe_2SO_6$$

What the other 17 or 18 per cent are could not be ascertained on account of the minute quantity of material. We hope to be able to secure more of this mineral from the Mimbres Mine, and also a sufficient quantity of utahite for a new analysis. At any rate, it is thought that the above data should be placed on record.

5. *Picropharmacolite, from Joplin, Mo.*

Mr. Edward D. Drown of this city presented me with a specimen which he had received as coming from Joplin, Mo. It occurs in incrustations upon a coarse-grained, cleavable dolomite which are from 2 to 15^{mm} thick and are composed of radiating silky fibers, forming botryoidal, globular or mammillary masses. The appearance of this incrustation and the results of the analyses indicate the probability of its being a mixture of several varieties of the same mineral,—which I had no means to separate.

That which is most uniform forms botryoidal crusts from 2 to 3^{mm} in thickness made up of radiating silky fibers in globular aggregations: the analysis I, a and b. In the cavities of the incrustation there are often very delicate silky fibers 2 to 3^{mm} in length, or the globules are covered with very minute acicular crystals. The analyses of botryoidal incrustations, more or less mixed with acicular crystallizations, are given in II, a, b, c. In analyses III, the radiating silky groups from another portion of the specimen are given, after the powder had been placed over H_2SO_4 for about one month. The material for each batch was carefully powdered, and thus uniformity was secured.

I. Specific gravity taken in alcohol was 2·583. The analyses gave:

	a.	b.	Mean.	Mol. Ratio.	
Insoluble	0·17	0·16			
Loss at 100° C.	11·60				
Loss at ignition	11·44	23·17	23·11	1·284	6·2
CaO	22·40	22·44	22·42	0·404	1·95
MgO	6·60	6·68	6·64	0·164	0·79
MnO_2	0·21	0·31			
As_2O_5	47·48	47·73	47·60	0·207	1·0
	99·90	100·49	99·77		

These results indicate the presence of a small quantity of basic hydrogen, replacing calcium and magnesium; taking this view, the following closely agrees with the results of the analyses: $(H_2CaMg)_3As_2O_8+6H_2O$, which is the composition of picropharmacolite.

6·— H_2O	108	22·34 per cent.
0·25 " basic	4·5	0·93
1·95 CaO	109·2	22·59
0·79 MgO	31·6	6·54
1·— As_2O_5	230·	47·60
	483·3	100·00

II. Analyses of crusts mixed with globular aggregations:

	a.	b.	c.	d.	Mean.	Mol. ratio.	
H_2O		24·38	24·11	24·25	24·58	1·35	6·5
CaO	20·29	19·78	19·27	19·22	19·64	3·51	1·7
MgO	8·35	8·15	8·67	8·48	8·41	2·10	1
MnO_2	0·14	0·29	0·41	0·29			
As_2O_5	47·74				47·74	2·08	1
					100·37		

These analyses also show the replacement of calcium by hydrogen like the first two, and also a larger percentage of magnesia, while agreeing with the formula of picropharmacolite.

III. The material of analyses III was, on account of being interrupted with my work, placed for a month over H_2SO_4. It will be seen from the analyses given below, that it contained a still larger percentage of magnesia, and that in drying, one of the six molecules of water was lost.

	a.	b.	Mean.	Molecular ratio.	
H_2O	20·50	20·19	20·35	1·13	5·14
CaO	17·31	16·87	17·09	0·31	1·41
MgO	11·61	11·48	11·54	0·29	1·32
MnO_2	0·29	0·34			
As_2O_5	50·60	50·51	50·56	0·22	1
	100·28	99·39	99·54		

6. *Pitticite.*

At the Clarissa Mine, Tintic District, Utah, a mineral has been found occurring in cryptocrystalline masses, largely intermixed with limonite, and forming coatings made up of minute botryoidal groups, seldom over 1^{mm} in size, and having a lustrous crystalline surface. H = 3·5. Luster resinous to waxy, color brown to dark yellowish brown. Only with great difficulty comparatively pure material could be selected for the analysis which gave:

Insoluble	Fe_2O_3	4·08
	SiO_2	1·92
	H_2O	18·24
	As_2O_5	39·65
	SO_3	1·14
	CuO	1·17
	Fe_2O_3	33·89
		100·09

It will be seen that this mineral does not represent a mixture of ferric sulphates and arsenates, like the German varieties. The small quantity of sulphuric acid which is contained in it, is almost exactly required for the cupric oxide present to form chalcanthite; after deducting this, the quartz, and the insoluble ferric oxide as limonite, the composition is:

			Ratio.		Calculated.	Pure mineral.
H_2O	17·64	0·98	5·7	or 23	17·46	19·40
As_2O_5	39·65	0·172	1	4	38·80	43·11
Fe_2O_3	33·89	0 212	1·23	5	33·74	37.49
				Impurities	9·00	
						100·00
					100·00	

corresponding to: $4(Fe_2As_2O_8) . Fe_2(OH)_6+20H_2O$.

7. *The so-called Gibbsite from Chester County, Pa., a Phosphate.*

Hermann (Bull. Soc. Imp. Nat., Moscow, No. 4, 1868, 496,) publishes an analysis of a grayish pearly mineral, forming a coating of thin delicate concretionary crusts on limonite from the wavellite locality near White Horse Station, Chester Co., Pa., giving the following composition: Al_2O_3 63·84, H_2O 33·45, SiO_2 1·50, P_2O_5 0·91 and traces of MgO and Fe_2O_3.

From some preliminary tests which I have made, it appeared that all the so-called gibbsite from this locality is a phosphate. It forms fine pearly scales and very thin incrustations of pearly scales upon wavellite and limonite. Unfortunately, although very liberally furnished with material by numerous friends, the quantities obtained from about half a dozen different specimens, varying from 0·07 to 0·27 of one gram, gave such discordant results that I could not arrive at a definite conclusion as to its composition. The quantities of the different constituents gave, as follows:

Al_2O_3	from	34·60	36·28	37·51	38·09	41·25	42·64
P_2O_5	"	27·77	28·71	29·13	32·51	33·29	35·88
H_2O	"	26·82	27·77	28·40	29·59	30·29	30·37

From all this it is evident that the only conclusion which can be arrived at at present is that the White Horse Station "Gibbsite" is a hydrous aluminum phosphate of an unknown constitution.

8. *Atacamite.*

Together with the ferric sulphates mentioned under 1, 2 and 3, Prof. Henry A. Ward brought from near Sierra Gorda, Chili, the most beautiful specimens of atacamite, both in perfect crystals and groups of thin laminated crystals, with cleavage planes as large as 15×10^{mm}, and of a deep green color. Prof. Ward kindly presented me with some of these groups for analysis. Sp. gr. = 3·740. The analysis gave:

				Ratio.	
Cl	16·18	or $CuCl_2$	30·58	0·228	1
CuO	73·93	CuO	55·91	0·630	3
H_2O	13·58	H_2O	13·58	0·754	3
	103·69				
Less O for Cl	3·64				
	100·05				

This closely agrees with: $CuCl_2.3Cu(OH)_2$.

Chemical Laboratory, 111 S. 10th street,
Philadelphia, May 11th, 1890.

ART. XXV.—*Chalcopyrite crystals from the French Creek Iron Mines, St. Peter, Chester Co., Pa.;* by S. L. PENFIELD.

DURING the past year some very unusual and interesting chalcopyrite crystals have been taken from the French Creek mines which are so unlike any that have thus far been described that they seem worthy of special notice. The author's attention was first called to them in the fall of 1889, by Mr. James Matters, superintendent of the mines, who has kindly furnished him with a number of interesting crystals, not only of this mineral, but also of pyrite,* as well as with a description of their mode of occurrence. The author takes great pleasure in acknowledging his indebtedness to Mr. Matters, and also to Messrs. C. S. Bement and Geo. L. English of Philadelphia, Pa., for the loan of interesting crystals from their own private collections.

The crystals which are frequently over one centimeter in diameter are built out in all directions and occur either in calcite, from which they can seldom be obtained without being broken, or in a fine fibrous or compact scaly material. The fine fibrous mineral is insoluble in acids, fuses like hornblende and is probably a variety of that mineral called byssolite; the compact scaly mineral is soluble in hydrochloric acid, fuses B. B. at about 3 to a black magnetic globule, contains only traces of magnesia, gives abundant water in the closed tube and is probably thuringite. The byssolite and thuringite fill cavities or pockets in the magnetic iron ore and are at times thickly beset with crystals of both chalcopyrite and pyrite, while again large quantities of the material may be examined without finding any. Most of the chalcopyrite crystals have the characteristic brass-yellow color, while some show a purple tarnish, and others are coated with a black oxide. The crystal faces are always striated parallel to their intersection with the positive and negative unit sphenoids, frequently causing a rounding or distortion of the crystals and entirely unfitting them for exact measurement on the goniometer.

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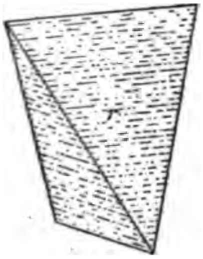
* Curiously developed Pyrite crystals: this Journal, III, xxxvii, 209.

The simplest type of crystal is the sphenoid *r*, 332, $\frac{3}{2}$ fig. 1. The angle of $r \wedge r$, $332 \wedge 3\bar{3}2$ measured approximately 130°, calculated from $c = 0{\cdot}9856$, 128° 52′. This same sphenoid *r* is at times found with its solid angles modified by the faces of a tetragonal scalenohedron ω, fig 2. By placing the arms of a contact goniometer along the longer pole edges of the scalenohedron it was found that they made an angle of about 155°, from which it was calculated that the sphenoid $\bar{1}16, -\frac{1}{6}$, would truncate the edges, while the vertical striations on the faces indicated their probable oscillation with the unit sphenoid, 111. By a combination of zones it was found that 576, $\frac{7}{6}-\frac{7}{5}$, would satisfy these conditions, and although it is not at all certain that this is the true symbol, fig. 2 gives one a fair idea of the habit of the crystals.

1.



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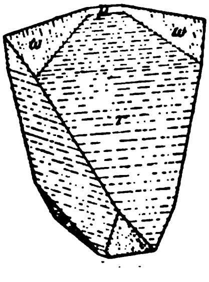

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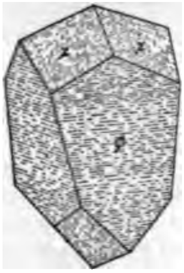
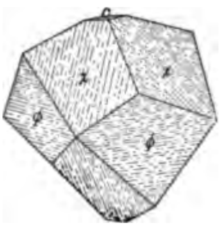


A very common type is represented in fig. 3. The sphenoid φ varies much in inclination in different crystals, in some it is nearly vertical like a prism, in others inclined almost as much as the $\frac{3}{2}$ sphenoid *r*. It is not at all certain, therefore, whether it is a prism, which tapers owing to oscillations with he positive sphenoid, or not. The faces are usually very little ounded or distorted by the striations and in the majority of ases have an inclination of $\varphi \wedge \varphi$ = about 25° measured over he base with a contact goniometer, agreeing closely with a ⅓ phenoid, which is the inclination given in the figure. The calenohedron χ is also much striated, and by placing the arms f a contact goniometer along the longer and shorter pole dges in a number of cases it was found that they made angles f about 140° and 90°, agreeing with the form 122, 1–2, in which the pole edges would meet at angles of 141½° and 87½°, and which is the symbol given to these faces in the figure. It s possible, however, that the faces are really pyramids of the econd order which have been distorted by oscillatory combinaions with the positive unit sphenoid 111. A basal plane, which is not shown in the figure, is frequently developed. A light modification of this type is represented in fig. 4, where he φ and χ faces are about equally developed. When the basal planes, *c*, are present they are always striated parallel to heir intersection with the negative sphenoid $1\bar{1}1$ as in the figure. When the base is absent the crystals look almost exactly ike the hemihedral form of the isometric trigonal-trisoctahedron *x* (122) ½(2), and there is no appreciable difference in the appearance or inclination of the φ and χ faces.

4.



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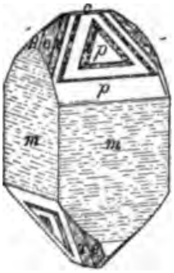

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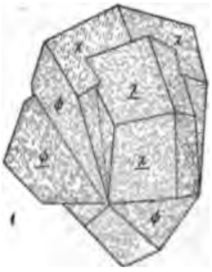
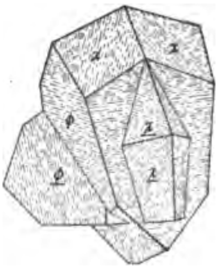


On some of the crystals the positive and negative sphenoid *p*, 111, 1 and *p'*, $1\bar{1}1$, −1, are well developed and give sharp reflections, while they also oscillate with other faces, giving rise to striation. Fig. 5 is intended to represent these crystals, a number of which were measured in hopes of finding definite symbols for the sphenoids and scalenohedrons. Measuring from *p*, $\bar{1}\bar{1}1$ over the base on to *p*, 111, no distinct reflections were observed except from *p* and *c*, but on continuing the revolution of the crystal on the goniometer beyond *p*, 111, there immediately followed an unbroken band of signals without any interruption or prominent parts between *p* and *m* 110. From this it may be assumed, that in all probability, the striated phenoids φ are prisms which have been very symmetrically tapered by oscillations with the positive unit sphenoid. Measuring in the zone between p, 111 and p' $1\bar{1}1$, starting from p there followed an unbroken band of signals which continued for about 35°, that is, from p, 111 to a pyramid of the second order e, 101, after which no reflection was obtained till p' was reached. From this it may be assumed that there is probably no definite sphenoid in this zone and that χ which we have assumed as 122, 1–2, results from the oscillations of e, 101 with p 111. Some of the accurate measurements between p, p' and c are as follows:

		Times measured.	Limiting measurements.	Average.	Calculated.
$p \wedge c$	$111 \wedge 001$	5	54° 4′–54° 27′	54° 19′	54° 20′
$p \wedge p'$	$111 \wedge 1\bar{1}1$	5	70° 2′–70° 22′	70° 10′	70° 8′

Twin crystals are not rare, the twinning plane being always a unit sphenoid. Two crystals with the habit shown in fig. 3, if symmetrically twinned about $\bar{1}\bar{1}1$, would appear as is fig. 6, with one projecting through the other, while in reality all which have been observed show a slight modification and adaptation in that the shorter pole edge of one individual is a continuation of the longer pole edge of the twinned crystal, fig. 7. The striations and lettering are the same as in figs. 3 and 4. A still more interesting twin is represented in fig. 8, where the principal crystal is a combination of a unit prism, m, and a pyramid of the second order, e, equally developed. In the upper, front, right hand octant three faces of a twinned individual occur, let into the principal crystal, as shown in the figure, while on both individuals the basal planes are present. To represent the crystal $\bar{1}\bar{1}\bar{1}$ has been taken as the twinning plane. On the reverse side the crystals show no penetration, and only three faces occur, one of which is a prism and two pyramids of the second order, these are equally developed, are striated parallel to their intersection with the unit sphenoid, and have their angles slightly modified owing to this oscillatory combination. These twins do not seem to be very rare and are

7.



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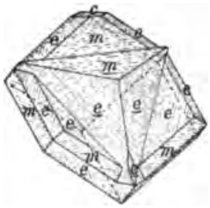

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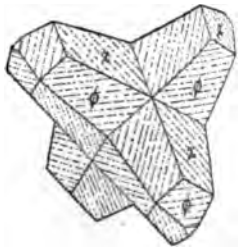

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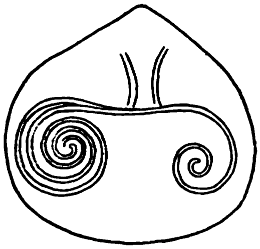

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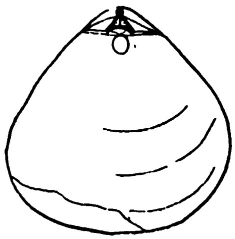

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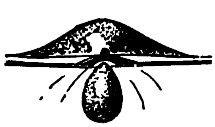

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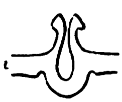

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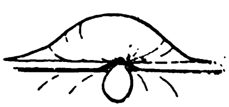

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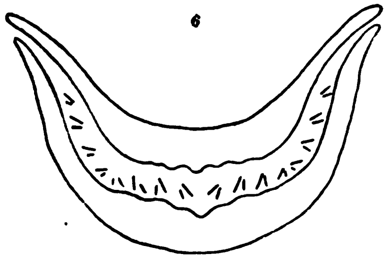

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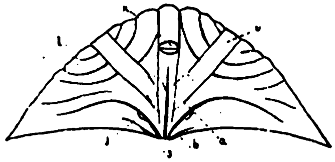

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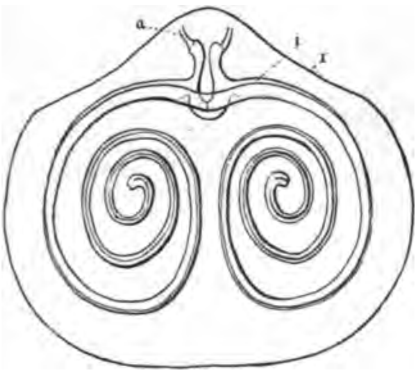

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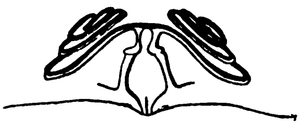

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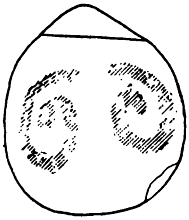
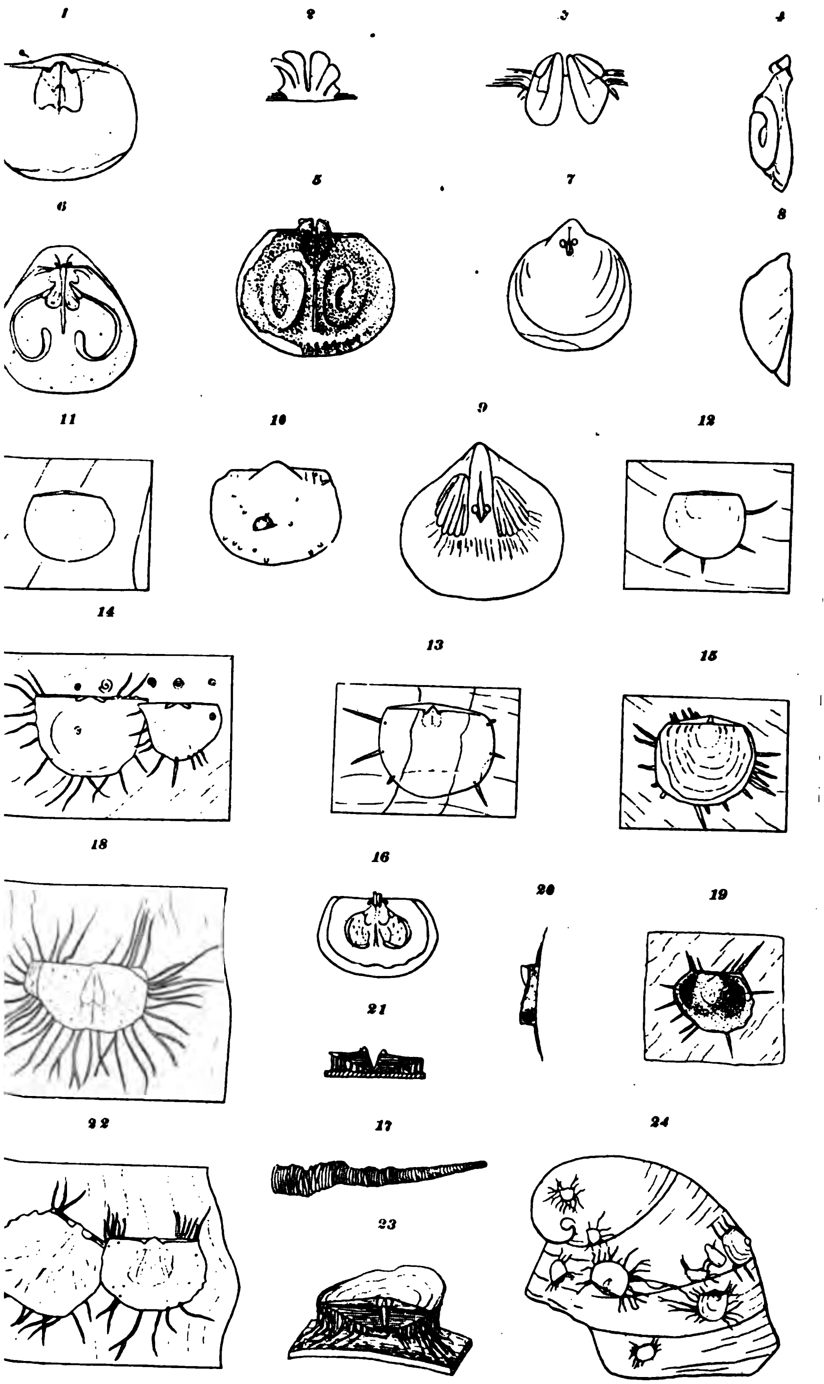


1, 2. AMPHICLINA.

3–10. KONINCKINA.

. Jour. Sci., Vol. XL, 1890. Plate IX.



1–5. Leptænisca.

6–24. Strophalosia.

ometrically developed. Looked at in the direction of the nning axis they have an hexagonal outline, showing a short :agonal prism of the second order in combination at one end h a simple rhombohedron and at the other with two rhomıedrons in twin position. This adaptation of a hemihedral ragonal mineral to hexagonal, rhombohedral symmetry is tainly very remarkable and reminds one of the tendency of : isometric copper to develop in a similar way.[*]

Fig. 9 represents a crystal with very remarkable habit, which in the Bement collection. It is striated, rounded and oxi:ed, so that only a general habit is preserved, which reminds e at first of a complicated fourling. No twinning, however, ıld be detected and a simple distortion or elongation of the rm shown in fig. 4 in the direction of the octahedral axes ɔms to explain this curious development. For simplicity ke the figure was drawn on isometric axes with a parameter *a* : 2*a*. A less symmetrical development of this same kind ves rise at times to very curious forms.

Pyrite and chalcopyrite crystals occur intimately associated ith one another at the locality. Some of the latter are coated, part, with a very thin layer of pyrite crystals, but no definite ientation of the two crystals could be detected. It is cerinly very remarkable to find at this one locality pyrite cryss imitating tetragonal and orthorhombic symmetry[†] and alcopyrite imitating isometric and hexagonal-rhombohedral nmetry.

Iineralogical Laboratory of the Sheffield Scientific School,
New Haven, April, 1890.

RT. XXVI.—*Koninckina and related Genera*; by CHARLES E. BEECHER, Ph.D. (With Plate II.)

DURING the year 1864, Professor O. C. Marsh made extenve collections from the celebrated locality, St. Cassian, in the pper Trias of the Tyrol. All these specimens he has recently aced in the hands of the writer for investigation. They ve been examined at the present time with special reference the brachiopods, which form one of the interesting groups this remarkable fauna.

The series of specimens representing the peculiar genera, *oninckina* and *Amphiclina* are rich in numbers and complete, the later stages of growth, besides furnishing some younger ells, which exhibit a few phases in development of considerle interest and importance. A critical study has resulted in ascertaining for the first time, so far as known, the true character of the internal brachial supports. They have been quite fully determined for *Koninckina*, and their presence is here first demonstrated in the genus *Amphiclina*.

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[*] This Journal, III, xxxii, 419.

[†] Loc. cit.

Koninckina Suess, 1853.—The general form and characters of this genus, as represented in the type species (*K. Leonhardi* Wissmann sp.), have been so frequently described by various authors as to necessitate no restatement in this place. The features which require further consideration are: the development of the hinge and beak, the internal calcareous brachial supports, the development of the spiral lamellæ, and the interior of the dorsal valve.

The beak has uniformly been described as imperforate and the hinge without an area.* This statement has come from the examination of fully mature individuals measuring 8^{mm} and upwards in length, in which these characters are so obscure, or involved, as to escape notice, without having previously carefully noted the characters presented by the young. In specimens 5^{mm} or less in length, the enrollment of the beak has not proceeded so far, and a study may be made of its principal features, proving the existence of the parts said to be wanting, and bringing the genus into more general harmony with the articulates.

Figure 3 shows the umbonal and hinge characters which can be observed in a specimen about 4^{mm} in length. The initial dorsal valve is shaded in the figure, and is the only convex portion of the valve, as succeeding growth produces a concave shell, making the concavity very pronounced in full-grown shells. It is evident that the growth-stages between the convex and concave form were much accelerated, as the line of demarkation is abruptly outlined with the completion of the nepionic stage.

The hinge is narrow, extending to the cardinal extremities. In the center is a triangular area, partially closed by a slight deltidial growth or deflection at the margins, and the apex of the ventral valve is perforate. The dorsal valve shows a much narrower hinge, and under the beak a slight callosity extending into the open area below. It will at once be noticed that the young, or neologic, stages of growth in *Koninckina* correspond to the adult, or ephebolic, conditions in *Amphiclina* and *Koninckella*.

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* Classification der Brachiopoden von Thos. Davidson, E. Suess, 1856, p. 93, "keine Area; kein Deltidium; keine Durchbohrung am Schnabel." Manuel de Conchyliologie (Fischer) Brachiopodes by D. Œhlert, 1887, p. 1292, "Sans aréa ni deltidium."

.s further evident that the extremely young, or nepionic
in all these genera, was biconvex in form, and furnished
a well developed area and opening for the protrusion of
edicle, thus agreeing with the conclusions reached by J.
larke and the author in a study of Silurian brachiopods.*
e perforation persists to maturity, but does not present
ncrease in size, and is probably of little functional im-
nce. No additional increase takes place in the hinge area,
ıt the final development of these parts may be considered
npleted in the early neologic period, subsequent to which,
nrollment of the beak serves more or less to conceal them.
e calcareous spiral lamellæ were first worked out by
ssor E. Suess† (see fig. 1), but the vascular markings
piral impressions on the interior of
alves had been well described and
rated before by Dr. Woodward.‡
thing has been added since, except
mportant discovery made by Herr
ıayer,§ that the lamellæ are double,
in the type species and in another
from the Hallstatt Beds.
e attachment of the primary lamellæ
hinge plate is by two slender, diverg-
ruræ, rising from the cardinal pro-
nearly at right angles to the plane
margin of the dorsal valve (see figs.
1 9). From their distal ends, the
ry lamellæ originate and extend directly forward for a
distance, and then are abruptly curved laterally, and
y downward, forming the beginnings or bases of the
cones. At the point of curvature, two processes are
off, which are marked at their origin by a notch, thence
ding inward, they are united at the central line forming
ɔop (figs. 5 and 8). The anterior portion of the loop is
rted or articulated with the median septum of the dorsal
apex of the cone. Both lamellæ are free, and disposed
closely follow the four volutions of the primary lamellæ
ɔop. They make an anterior curve in the middle, and
parently connected with, the center of the ventral side of
e secondary or accessory lamellæ take their origin at, and
, making a distinct facet, indicated by *x*, fig. 7.

1.

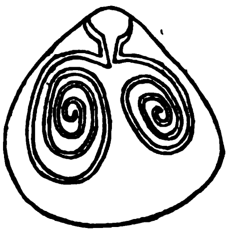

Figure 1.—*Koninckina Leonhardi* Wissm. Spiral lamellæ and supports, after Suess, *loc. cit.*

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moirs N. Y. State Museum, vol. i, No. 1, Oct., 1889. The Development
e Silurian Brachiopoda, p. 83.
. *cit.*, p. 83, tab. iii, fig. 25*b*.
nual of the Mollusca, p. 231, 1854.
ted by Davidson in British Fossil Brachiopoda. General Summary, p. 368,

at an angle of about thirty degrees with each other, opening toward the ventral side (fig. 6). On account of the shallow and deeply concave region occupied by the entire animal, the coils necessarily are directed ventrally, and the height of the cone is very slight. As actually measured in a specimen (fig. 6), the diameter of the cone of spiral lamellæ is 3·6^{mm} and its height is about 1^{mm}.

Figure 10 illustrates a small translucent specimen, showing the form and disposition of the spiral ribbon at this period of growth. No fact of special consequence is exhibited, except that the development of the spiral apparently agrees with that adduced for other genera. It will be noticed also, that the comparative area occupied by the simple coil of one and one-half volutions is as great as that in a mature specimen in which the number of volutions has increased to four.

The spiral impressions and vascular lines on the interior of the body of the dorsal valve have been so often studied and illustrated that there only remain for consideration the special features within the beak and umbonal regions. On account of the smallness of the specimens and the partial obscurity of some of the markings, all the details which should be observed have not satisfactorily been made out, and this is especially true of the muscular scars, as no well-defined muscular areas can be detected in the specimens examined. It is supposed, however, that the poorly defined regions, indicated by *a* in fig. 7, at the ends of the vascular trunks *v*, represent the adductor scars, but they are so involved with the septum and vascular markings as to be very indeterminable. The septum *s* begins at the beak, and is angular over the umbonal region, and rounded over the body of the valve, terminating in the anterior third of the length of the shell. At *x* is indicated the articular indentation for the loop, as previously mentioned. The two widely divergent cardinal processes *j* become merged into the general surface of the valve before reaching the hinge extremities. Under their apices are situated the dental sockets *b*, and on the summits above are the bases of the processes supporting the ribbons.

Some notice should be taken of the species described by Swallow as *Koninckina Americana** from the Kaskaskia group, since it is the only American form which has been referred to the genus. Only the ventral valve was observed, and was described as having a punctate shell structure, and a "few short depressed spines near the borders," neither of which characters are found in *Koninckina*, but are so evidently productoid in their nature that the species probably should be d with *Productus*. In the same paper, Swallow describes *oductus* with a like specific designation (*P. Americanus*), o avoid duplication, the name *Productus Swallovi* is here osed for the species described as *Koninckina Americana*.

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* Transactions of the Academy of Science of St. Louis, vol. ii, p. 94, 1863.

nphiclina, Laube, 1865.*—This genus agrees very closely l its essential features with *Koninckina*, so far as can be ved from the material studied. The hinge and beak chars, represented in fig. 2, differ little from those shown by oung of *Koninckina*, except that the area is higher, and eltidial plates well developed. This last condition is exed by the erect position of the beak, which in that genus much incurved as to prevent the normal growth of deltiplates.

arly all well-preserved specimens, both of the type species *ubia* Münster and *A. Suessi* Laube show distinctly the ence of spirals, and several sections have been made preng features similar to those represented in fig. 6 of *inckina*, in which the primary and secondary lamellæ and osition of the apex of the cone are well displayed. Fig. f a young specimen in which the lamellæ on the left side become displaced so that a double series of spirals results, on the right side they are superimposed in their usual ion. Fully matured individuals have four volutions in ibbon as in the preceding genus. The attachments of the llæ could not be made out distinctly, but they apparently no peculiar features.

om the position and size of the spiral cones, it is evident the impressions described by Laube (loc. cit.) as muscular on the interior of the dorsal valve, must be otherwise coned; and it is naturally inferred that they represent ridges urrows limiting the brachial regions, the diverging cardirocesses, and the vascular impressions. The parts about nterior of the dorsal beak agree with those represented in for the preceding genus.

is therefore apparently necessary to deal with *Amphiclina Koninckina* as very closely related forms, and undoubtedly ging to the same patronymic group.

e first consideration of genera related to this group ally deals with such forms as have previously been ed with the Koninckinidæ. Only the classifications prol by a few of the leading authorities need be discussed in lace.

vidson, in his Introduction to the Classification of the iopoda, 1851–54, p. 92, proposed the family Koninckinidæ for the single genus *Koninckina*. The same author, in 1884, published a tabular classification in the General Summary to the British Fossil Brachiopoda, p. 354, in which, under the family Spiriferacea, the sub-family Koninckinidæ is given containing the three genera *Anoplotheca*, *Koninckina*, and *Koninckella*.

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* Die Fauna der Schichten von St. Cassian, II Abtheilung, p. 28, 1865.

Woodward, in the Manual of the Mollusca (1854), placed *Koninckina* as a sub-genus under *Strophomena* in the family Orthidæ, and also include *Davidsonia* in the same group.

Dall, in 1877,* included *Koninckina*, *Anoplotheca*, and provisionally *Davidsonia*, in the family Atrypidæ.

The classification of Waagen† resembles that proposed by Dall, but under the Atrypidæ he includes *Koninckina*, *Anoplotheca*, and *Koninckella* in the sub-family *Koninckininæ*.

Zittel‡ arranges *Anoplotheca*, *Koninckina*, and *Thecospira* under the Koninckinidæ, and also places *Amphiclina* and *Davidsonia* with the Strophomenidæ.

Finally, Œhlert, in 1887 (loc. cit., p. 1291, et seq.), adopts the family Koninckinidæ, putting it between the Strophomenidæ and Spiriferidæ, and including the genera: ? *Davidsonia* Bouchard-Chautereaux, 1847; *Koninckina* Suess, 1852; s. g. *Anoplotheca* Sandberger, 1856; *Koninckella* Munier-Chalmas, 1884; ? *Amphiclina* Laube, 1866; ? *Thecospira* Zugmayer, 1880; and ? *Cœlospira* Hall, 1863.

This grouping is the most comprehensive of those cited, as it adopts all the genera which have previously been placed intimately with *Koninckina*, and besides, it includes the additional genera *Amphiclina* and *Cœlospira*, although the former was thus correlated by Davidson, but not included in his general tabular classification as the presence of spires had not then been shown.

In treating the various members of this family as defined and limited by Œhlert, we believe that the general idea of the group, as expressed by the characters of the leading genus, is a comprehensive one, but there are yet some discordant and uncertain elements. Also, a more discriminating diagnosis may now be given, and the relations of the family (or sub-family) to other important groups become more apparent while its genetic history is more or less clearly indicated.

Of course, much depends upon the taxonomic value which is to be allowed to the various features of the shell, and in the present instance we shall endeavor, in the main, to follow the rank generally adopted by recent authorities.

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[*] Bulletin U. S. National Museum, No. 8. Index to the names which have been applied to the subdivisions of the class Brachiopoda, p. 78, 1877.

[†] Geological Survey of India. Carboniferous fossils of the Salt Range, p. 447, 1883.

[‡] Handbuch der Palæontologie, I Bd., p. 680, 1876–80.

Before discussing the position held by the genus *Davidsonia*, attention is called to the development of the deltidium and pseudo-deltidium, or pedicle-sheath. It has been shown by J. M. Clark and the writer (loc. cit.), that all the species, so far as examined, possessing a true deltidium in the adult state, show that it was gradually developed in early stages of growth, by concrescence along the lateral margins of an open triangular area. Also that all species furnished with a pedicle-sheath have it fully developed in the earliest growth-stages which have been observed for these species, and the subsequent growth of the individual does not materially alter its general characters, except that it is sometimes retrogressive, the parts becoming atrophied or functionally obsolete. A feature of such importance, and so intimately connected with the embryonal growth of the shell, must be given considerable significance in discussing the various genera in which it is present or absent.

Davidsonia has always been described as having the area covered by a pseudo-deltidium, and this is the first objection to the grouping of the genus with *Koninckina* and *Amphiclina*. So far as known, the arms were not supported by a calcareous ribbon, but were fleshy and perhaps movable, as in *Rhynchonella*, and furthermore, no true spire-bearing form has yet been shown to have a pedicle-sheath. With our present information, exception must be made for *Thecospira*, but farther nvestigation in that genus may result in proving it to have deltidial plates, as has been accomplished in *Spirifer* and *Spirferina*,* although these genera have commonly been decribed as having a pseudo-deltidium, as in strophomenoid hells. The muscular system of *Davidsonia* corresponds more closely with the Strophomenidæ and Productidæ than with pire-bearing genera, and in view of these facts collectively we eject *Davidsonia* from the Koninckininæ.

The genus *Koninckella* should remain as placed, as all its haracters harmonize with those included in our present understanding of the leading genus of the group. Formerly the presence of a well-developed hinge area and pedicle perforaion in this genus did not agree with the characters ascribed o *Koninckina*, but this objection is now removed.

Of the three remaining genera little of a positive nature an be stated without further examination of material. The descriptions and figures of *Anoplotheca* which have been given re not sufficient to exclude the genus nor to show that it ctually belongs here. *Cœlospira*, however, has been clearly hown by Davidson to be closely related to *Atrypa* and *Zygo-*

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* Development of some Silurian Brachiopoda, pp. 78–89.

spira, and this position is further fortified by recent investigation. *Thecospira* has been mentioned as furnishing an apparently abnormal character in the presence of a pedicle-sheath, to which should be added its condition of fixation by the ventral valve, and the punctate shell structure. Otherwise the features described and illustrated by Zugmayer appear to agree in all essential particulars with *Koninckina*.

Therefore, it is believed, that the genera *Davidsonia* and *Cœlospira* should be omitted from the family, and that *Thecospira* and *Anoplotheca* should be allowed to remain tentatively until further information is obtainable.

The relations of the genus *Kayseria* (Davidson, 1882,) to this group have previously been discussed simply with reference to the duplicate nature of the spirals,* but from what has been shown regarding the attachments and the loop of the primary lamellæ, as well as the articulation with the dorsal septum, and the additional hinge characters in *Koninckina*, further important relationships may be adduced which it is believed will remove *Kayseria* from the Athyrinæ, and place it with the forms treated of in the present paper. In a recent study of *Kayseria*, the writer has found no particular in which to change the details of the spirals so completely determined by the Rev. N. Glass for Mr. Davidson.† The only additional features to be noted are relative to the shell, and consist of a collosity under the dorsal beak forming the median septum, the well-developed cardinal processes, and the impunctate structure of the test. A comparison in the light of those facts reveals a striking similarity in most of the important features.

The position of this group in the last systematic arrangement of families and genera proposed by Davidson now seems to belong, not at the end of the Spiriferacæ as placed, but immediately following the Athyrinæ and preceding the Atrypinæ. It is not necessary in this place to discuss the merits of these groups to rank as families, and the importance accredited to them by Davidson is here retained.

Sub-family *Koninckininæ*, emend.—***Diagnosis.*** Ventral valve perforate and with a hinge area, sometimes obscured by the involution of the beak, with or without deltidial plates. Dorsal valve with cardinal processes and median septum, upon some point of which the loop of the primary lamellæ articulates. Brachial supports composed of two primary lamellæ connected by a loop from which originate two secondary lamellæ, extending to the apex of the spiral and following its

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* British Fossil Brachiopoda, General Summary, p. 369, 1884.

† Ibid., Supplement to the Devonian Brachiopoda, pp. 22–23, 1882.

ıtions. Shell in the principal genera impunctate. Including
genera: *Koninckina*, *Koninckella*, *Amphiclina*, *Kay-
a*, *? Thecospira*, *? Anoplotheca.*

.le University Museum, May 22, 1890.

EXPLANATION OF PLATE II.

AMPHICLINA DUBIA Münster, sp.

RE 1.—Ventral view of translucent specimen, showing attachments of principal lamellæ to hinge plate and spiral coils. On left side, primary and secondary lamellæ have become separated, making double spiral. × 6.

RE 2.—Dorsal view, showing nepionic dorsal valve, dorsal callosity, and hinge area, deltidium and pedicle perforation of ventral valve. × 6.

KONINCKINA LEONHARDI Wissmann, sp.

RE 3.—Cardinal view of portion of young specimen, showing nepionic convex dorsal shell, dorsal callosity, area, and characters of ventral beak. × 18.

'RE 4.—Similar specimen, showing slightly different features. × 18.

RE 5.—Dorsal view of bases of the two primary lamellæ *l*, with loop. × 6.

'RE 6.—Transverse section through a shell retaining both valves in position, showing cross sections of the lamellæ of spiral ribbon. The continuous and separate character of the primary and secondary lamellæ, and their inclination to each other, are well represented. × 6

RE 7.—Posterior view of interior of dorsal valve showing teeth sockets, *b*, cardinal processes, *j*, adductor muscular scars. *a*, main trunk of vascular impressions, *v*. septum, *s*. indentation or articulating surface supporting dorsal edge of loop, *x*. × 6.

RE 8.—Ventral view, showing form and attachments of spiral coils. The portion of loop and primary lamellæ (*l*) concealed by secondary lamellæ (*l'*) are represented by dotted lines. × 6.

'RE 9.—Cardinal view of coils with ventral side uppermost, showing supports and attachment of primary lamellæ. Secondary lamellæ are represented by heavy black lines. × 6.

JRE 10.—Dorsal view of young translucent specimen, showing form of spirals at this stage of growth. × 6.

e specimens figured are in the Yale University Museum, and are all from the
ᵉr Trias, of St. Cassian.

r. XXVII.—*The effect of pressure on the electrical conductivity of liquids*; by C. BARUS.

. BY subjecting commercial mercury to pressures between
ıtm. and 400 atm., isothermally, I found $-\delta R/R = 30 \times 10^{-6}$
where $-\delta R/R$ is the decrement of the specific electrical
stance R, corresponding to the pressure increment δP.
, is the symbol of volume, then from results of Grassi and
ers,* $-\delta v/v = 3 \times 10^{-6} \delta P$. Hence $\delta R/R = 10\ \delta v/v$.

3y using the later results of Amaury and Descamps, Amagat, Tait, I should
naterially change the remarks of the text.

If θ be the symbol of temperature, the following approximate results apply, isopiestically, at ordinary temperatures and pressures: $\delta R'/R'=800\times10^{-6}\ \delta\theta$; $\delta v/v=180\times10^{-6}\ \delta\theta$. Hence $\delta R'/R'=4{\cdot}4$, $\delta v/v$, where R' refers to electrical resistance considered in its thermal relations.

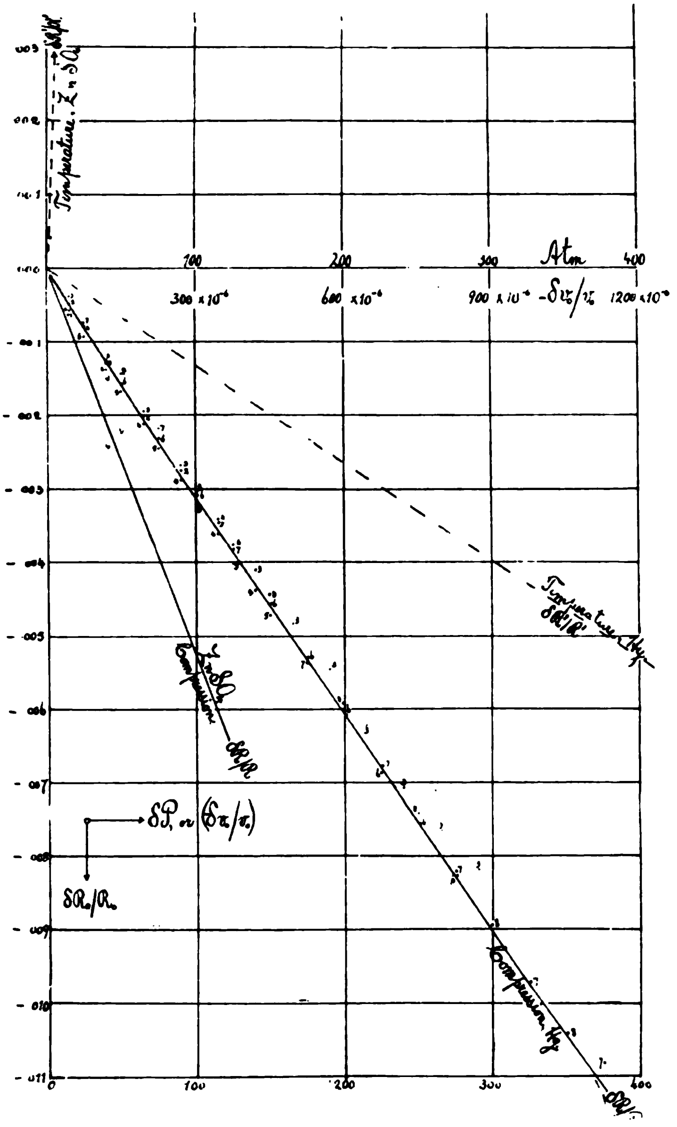
2. Again by subjecting a concentrated solution of zinc sulphate to pressures between 10 atm. and 150 atm., isothermally, I found less accurately, $-\delta R/R=50\times10^{-6}\ \delta P$. The other relations corresponding to the above must be estimated: $-\delta v/v=50\times10^{-6}\ \delta P$, $-\delta R'/R'={\cdot}04\ \delta\theta$, and $\delta v/v=200\ \delta\theta$. The chief magnitudes are here different in order and even in sign from those applying for mercury. For this reason the estimate made is sufficient for the following remarks.

3. The liquids were compressed in capillary glass tubes, and allowance made for the volume changes of glass. In case of mercury I used a tubular steel piezometer of special construction, containing filamentary glass tubes. In most of the experiments the steel tube was surrounded by a jacket of circulating cold water; but this precaution was not found essential.

To save space I will lump my results in a graphic diagram. With mercury I made eight series of measurements, using two different Bourdon gauges for pressure measurement. The first of these was graduated between zero and 300 atm., and the other between zero and 1000 atm. The chart, in which the observations corresponding to the different series are numbered, shows the gauges to have been in satisfactory accord. Otherwise there would be some obvious divergence between the data of series 1 to 6 made with the first gauge, and those of series 7 to 8, made with the other gauge.

The chart is easily intelligible. The abscissas denote either pressures in atmospheres, or volume decrements per unit of volume. The ordinates are the corresponding decrements or increments of electrical resistance per unit of resistance. The curves for compression are in full lines and may be coördinated either with pressure, or with volume decrement. The curves for thermal changes of resistance ($\delta R'/R'$) are given in broken lines and can only be coördinated with volume decrement. All the loci are nearly linear, seeing that the pressure interval is less than 400 atmospheres.

4. An inspection of the chart shows at once, that to bring the compression loci into coincidence with the thermal loci, the former must be rotated around the origin in a direction contrary to the hands of a watch. The angle of rotation is considerably greater for zinc sulphate solution, than it is for mercury. From this follows the remarkable result, that both in the case of the metal and of the electrolyte, the effect of isothermal compression is a decrement of resistance nearly pro-



Decrements of electrical resistance, in terms of volume decrements.

portional to pressure; and by deduction, that the immediate electrical effect of rise of temperature, $\delta R'/R'-\delta R/R$, is a decrement of specific resistance both in the case of the metal (Hg) and of the electrolyte ($ZnSO_4+Aq.$). This points out an inherent similarity between the metallic and the electrolytic conduction, in this instance.

5. In J. J. Thomson's expression for specific resistance $R=\sigma=(2\pi\ \beta/K)\ (q/mx)$, suppose to fix the ideas, that β, K and q are constant; whereas m, the number of molecules splitting up per unit of volume per unit of time, and x the distance passed over by the partial molecule moving at a mean velocity c during the interval of freedom t, are regarded variable. Clearly x can not be independent of m. Taking active molecules alone into consideration, supposing them to be symmetrically distributed and to move parallel to each other, $x=\sqrt[3]{1/mt}$. It follows that $R=(2\pi\,\beta q/K)\,x^3/c$. This is in accord with the above data. Reduction of volume, $-\delta v/v$, isothermally by pressure, diminishes x only. Reduction of volume isopiestically by cooling, diminishes both x and c. Hence the greater diminution of R in the former instance (pressure). Finally, by partial differentiation under the given conditions (dR/dm) $=-(4\pi\,\beta q/3K)\ \sqrt[3]{t/m^5}$. From this it may be conjectured (conjectured because t and m are not independent of each other), that the effect on R of an additional number of molecules splitting up, decreases rapidly with the total number, m, splitting up; i. e. that the numeric of the immediate electrical effect of temperature, $\delta R'/R'-\delta R/R$, is smaller for the metal than for the electrolyte. This also is in accord with the above data.

6. For solids I have only found available data in the case of copper. According to Chwolson,* $-\delta R/R=1{\cdot}3\times10^{-6}\ \delta P$. From Everett's tables $-\delta v/v={\cdot}6\times10^{-6}\ \delta P$. Hence $\delta R/R=2\delta v/v$. On the other hand $\delta R'/R'={\cdot}004\ \delta\theta$, and $\delta v/v=52\times10^{-6}\ \delta\theta$, whence $\delta R'/R'=77\ \delta v/v$. Hence $\delta R/R-\delta R'/R'$ is negative in case of the solid metal. Comparing with § 5 it appears that dR/dm probably passes through zero into a negative region, in proportion as the number of paths which the current can take is indefinitely increased.

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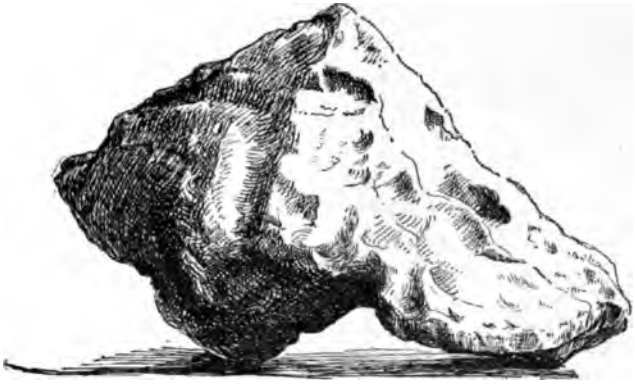
[*] Chwolson: Carl's Rep., xiv, p. 26, 1878. In case of mercury, the only kindred results I found are due to Lenz (Stuttgart, 1882). But they are unfortunately inaccessible.

RT. XXVIII.—*Notice of two new Iron Meteorites from Hamilton Co., Texas, and Puquios, Chili, S. A.;* by EDWIN E. HOWELL.

1. THE HAMILTON CO. METEORITE.

IN June of last year we secured from Professor Edgar Ever-rt, of the University of Texas, an iron meteorite which, wrote us, was found in Erath Co. of that State. It appears, wever, that the iron was really found in the northern part of amilton, the adjoining county.

Mr. J. D. St. Clair, of Alexander, Erath Co., who as agent r the discoverer, sold the meteorite to Professor Everhart, s kindly furnished me with the following facts. In April, 87, while plowing in his field about five miles south of Carl-n, Hamilton Co., Texas, Mr. Frank Kolb struck with his ow what he at first supposed was a stone, but which proved be the meteorite in question. Whether or not he had any ea of its true nature does not appear, but he seems to have ept it about a year before turning it over to Mr. St. Clair to ll it for him.



Hamilton County Meteorite, ⅙ natural size.

When the meteorite reached us it weighed 179 lbs. (81½ kilos), id was entire with the exception of a few ounces cut off by rofessor Everhart for analysis, which he seems not to have id time to complete. The thinner end had been pounded nsiderably and some small fragments may have been detached that when found the weight might possibly have been 180 s. The two greatest dimensions are 17½ and 13 inches 1×33 centimeters).

The general form is well shown in the accompanying cut, e underside is smoother and less sharply pitted than the upper side, which was probably the forward portion during the latter part of its flight, but the iron although very little oxidized shows none of the characteristic striæ and ridges seen in irons that have recently fallen.

The amount of troilite found in cutting the iron is not great, and seems to be all distributed in comparatively thin narrow plates, no nodules having been seen. The largest example is 6 inches in length and less than ¼ inch in average thickness, with an unknown width of certainly over 2½ inches. It is quite irregular in outline and terminates at one end in a star with points about ½ inch long. This form, which is very suggestive of certain crystallizations of marcasite, seems to be quite persistent, showing substantially the same in different sections for 2½ inches without any indication of coming to an end, any more than the plate with which it is connected.

The Widmanstätten figures are brought out with remarkable quickness on the application of very dilute acid, and are surpassed in beauty by no iron with which I am familiar. They resemble somewhat the markings on the Trenton and Murfreesboro irons, but more closely those of the Descubridora. The lines are thinner, however, and the inclosed figures smaller and more elongated, being in many parts a mere thread 5 to 8^{mm} in length. In this respect different parts of the same section vary greatly. Some of the inclosed figures are beautifully marked with the fine lines noted by Dr. J. Lawrence Smith first on the Trenton iron and called by him Laphamite markings.

The analyses of this and the following iron have been kindly furnished by Mr. L. G. Eakins of the U. S. Geological Survey, through the courtesy of Professor F. W. Clarke, chief chemist. Analysis by L. G. Eakins.

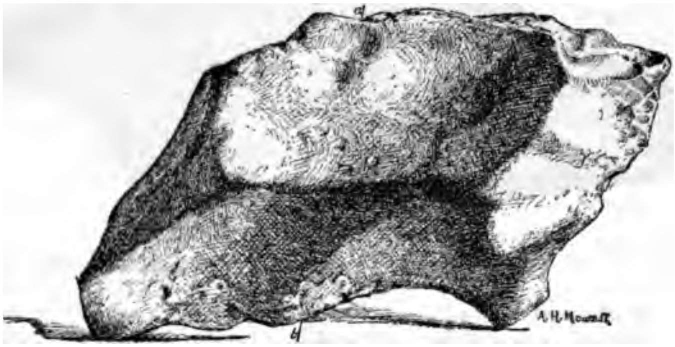
Fe	86·54
Ni	12·77
Co	0·63
Cu	0·02
P	0·16
S	0·03
C	0·11
	100·26

Specific gravity 7·95 at 27°.

2. The Puquios, Chili, Meteorite.

This iron was purchased by Professor Ward from the wife of Enrique Ravenna at Copiapo, Chili, April 26th, 1889. According to Señora Ravenna's statements it was found by her husband four or five years before—probably in 1884, near Puquios, and had been kept by them until secured for the Ward and Howell collection.

The iron reached us in an absolutely perfect condition. It had apparently lain for a considerable time half buried in the soil with its upper surface exposed to the weather and drifting sand which combined to bring out the structure of the iron without oxidization, making an exceedingly interesting and attractive object.

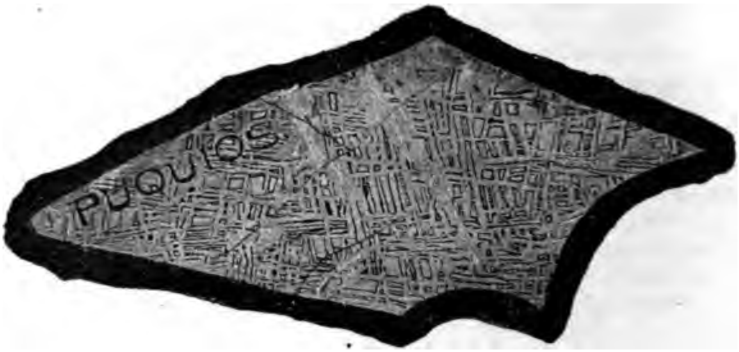


Puquios Meteorite, ⅓ natural size. The line *a*, *b*, indicates where section was made.

The general form of the meteorite is such as might result from the wearing away of a rhombic prism, one end wearing thinner than the other. (See accompanying cut.) The surface is unusually smooth, showing only a few shallow pittings. The two largest diameters are 10 and 5½ inches (25½×14 centimeters), and the weight was 14 lbs. 7½ ozs., or a trifle over 6½ kilos.

Although the surface of this iron is unusually interesting, the interior proves to be still more so. The etched sections show that the mass has been subjected to fracture and dislocation, resulting in a distinct and undoubted "faulting" of the Widmanstätten figures, and of the troilite. Most of these faults are so small and faint that they cannot be reproduced in an illustration, but are clearly seen with a pocket lens. The following cut of one of the etched sections, ¾ natural size, and produced by photographic process, shows three of these lines of faulting which is the especially interesting feature of this meteorite. So far as I am aware these are the first faults noted in an iron meteorite.

The novelty of this phenomenon and the exceeding toughness of meteoric iron, making a sharp fault seem almost an impossibility, require that the evidence of such a fault should be clear and conclusive before its acceptance as a fact; and such is fortunately the case. The largest fault is seen in successive sections for 2½ inches, or as far as the iron has been cut, and apparently extends the entire length of the mass, the throw of this fault is nearly ⅛ of an inch (3^{mm}). Careful examination reveals some crushing and branching along this line,



Section of Puquios Meteorite, ⅔ natural size.

and other parts of this section and other sections show small fractures with slight displacements.

These faults are clearly not produced by the impact of its fall upon the earth, but are a part of its earlier history, and in the light of some experiments made two years ago with Toluca iron I would suggest the probability that they were made when the iron was very hot—perhaps in its passage near the sun. I found that a piece of Toluca iron, although very tough when cold would crumble under the hammer when heated to a white heat. If we assume that the faulting of this meteorite took place under similar conditions of heat it seems necessary also to assume a contact with some other body.

The Widmanstätten figures call for no special remarks as they are sufficiently shown in the illustration. Suffice it to say that they are produced very readily with weak acid, that the finer lines inside the figures are unusually well developed, and are sometimes seen running parallel to the adjacent sides. Analysis by L. G. Eakins.

Fe	88·67
Ni	9 83
Co	·71
Cu	·04
P	·17
S	·09
Si	tr. (?)
C	·04
	99·55

Specific gravity 7·93 at 25·2° C.

ART. XXIX.—*The Cretaceous of Manitoba;* by J. B. TYRRELL, M.A., B.Sc., Geologist on the Geological Survey of Canada.

STRETCHING northward through the western portion of the province of Manitoba, the escarpment of the Pembina, Riding, Duck and Porcupine Mountains has long been known as the approximate eastern outcrop in that province of the Cretaceous terranes that underlie the whole country westward to the foot of the Rocky Mountains. The terranes have also been known to consists of shales of more or less varied character, and most of these shales have been considered as representing the Fort Pierre shales of Meek and Hayden, or the Pierre shales of the Canadian geologists.

During the summers of 1887 and 1889 the writer was engaged in field work in northwestern Manitoba, and part of the time was spent in studying the structure of this escarpment in the few natural sections cut by the streams flowing eastward into Lake Winnipegosis, and for a short distance in the banks of the valleys of the Assiniboine and Bird-Tail Rivers. A few sections in southern Manitoba were also hastily visited, and the logs, with typical specimens, were obtained of the well bored on the north side of the Riding Mountain by the Manitoba Oil Co., and of the well that is now being drilled at Deloraine in southwestern Manitoba.

Most of the natural exposures are comparatively low and disconnected, so that it is rarely possible to obtain the exact thickness of the different terranes, but the following notes will give a general idea of the relationships of the different beds, and an approximate idea of their thickness.

In northwestern Manitoba the Cretaceous rests unconformably on a floor of Paleozoic limestones and dolomites, which, wherever seen, were found to be of Middle or Upper Devonian age. These limestones are well shown around the shores of lakes Manitoba and Winnipegosis, and are always lying moderately horizontal, but much broken by small faults. The pre-Cretaceous surface of the limestone is everywhere uneven having been very severely eroded between Devonian and Middle Cretaceous times, and as is shown by these irregularities, the erosion was still in progress up to the time when the country was immersed in the Cretaceous sea. Besides the local irregularities the pre-Cretaceous floor is shown by borings to have a general light slope toward the southwest or west.

The Cretaceous of Manitoba falls very well into the groups that were first marked out by Messrs. Meek and Hayden, the Fox Hills Group being the only terrane that has not yet been recognized. The following are the groups with their approximate maximum thicknesses.

Laramie?		
Pierre	Odanah	500 feet.
	Millwood	500 "
Niobrara		540? "
Benton		130 "
Dakotah		200 "

The Dakotah Group, resting unconformably on the limestones of the Devonian, is composed of white or reddish sandstones either cemented by a calcareous matrix or often quite incoherent, being then an even-grained white quartzose sand. This grades up into a light green and rather hard sandstone, commonly interstratified with thin bands of shale.

Very few fossils have been found in this sandstone, and what have been found are confined to the greenish upper beds. They consist chiefly of carbonized fragments of wood and coniferous leaves; but the following animal remains have also been collected, viz: *Lingula subspatulata ?* H. & M., *Ostrea congesta*, Con., *Modiola tenuisculpta*, Whit. and cycloid scales of fishes.*

The terrane can be seen in several exposures along the foot of the northern portion of the Cretaceous escarpment, and at a small island known as Pemican Island in lake Winnipegosis, forty-four miles east from the foot of the escarpment there are evidences of the presence of this or the overlying group. The exposures seen were altogether too few and small to allow of any exact determination being made of the total thickness of the group, but on account of the irregularities of the floor on which it was laid down it certainly varies greatly even in short distances. Near the northwest end of Lake Winnipegosis it has probably a maximum thickness of two hundred feet, while on the north side of the Riding Mountain, where it was passed through in the Manitoba Oil Co's well on Vermillion River, it has, so far as can be determined from the few specimens at hand, a thickness of fifty-five feet.

South of this point, which is almost on the line of the 51st parallel of north latitude, these sandstones have not been recognized in the province, but as they are again reported as occurring in Dakota and farther south, they are in all probability continuous throughout the Cretaceous areas of Manitoba.

Overlying the sandstones of the Dakota, the Benton Group occurs as a band of dark gray, almost black, shale holding a

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* For the determination of all the fossils in the paper, except the Foraminifera and Radiolaria. I am indebted to Mr. J. F. Whiteaves, the Paleontologist of the Canadian Geological Survey.

:able quantity of carbonaceous material. This shale is bedded and breaks down readily into thin flakes, on ıccount it generally forms sloping banks. With the ales are associated thin beds of white soft sweet-tasting ian clay. In the borehole on Vermilion River the Ben-)ears to be 130 feet thick, and farther north, on the the Duck and Porcupine Mountains, it continues of he same thickness. It is easily recognized, even when .ked exposures are absent, by its characteristic property king into more or less minute graphite-like flakes, and ıthering immediately into a soft clay as usually occurs ess consolidated beds of the Pierre.

ıe Deloraine well this terrane has been recognized in ns from a depth of about 1300 feet. Up to the present ırs to be quite destitute of fossils, and ironstone or lime- odules were also only found in one or two localities.

Niobrara Group conformably overlies and is an upward)n of the Benton. The character of the rock, however, of being a soft fissile shale with little or no admixture .reous material, is a lighter gray calcareous shale or marl, nes varying to a band of moderately hard limestone. especially the case at the top of the formation where a grayish chalky limestone is generally met with. This often highly charged with pyrite.

rock throughout is strongly marked by the presence of number of Foraminifera belonging to such genera as *rina*, *Textularia*, etc., and of the larger fossils a gigantic *mus* is very common, while *Ostrea congesta*, *Belemni- anitobensis*, *Ptychodus parvulus*, *Enchodus Shumardi*, *ıdocyclus occidentalis* have also been recognized.

)utcrop of this terrane has already been recorded in ba by Dr. Dawson from the Boyne River, twenty-five .orth of the 49th parallel of latitude. Dr. Selwyn has zed its occurrence on the Assiniboine River thirty miles ’ortage la Prairie, and Dr. Spencer also discovered it in ey of Swan River. South of the 51st parallel of lati- ıe Riding Mountain has not been examined, but from ıre River northward, along the face of the Riding, Duck rcupine Mountains, this formation is easily recognized valleys of many of the streams that cut deep gorges ı the drift. It often weathers out in steep or vertical ıd may easily be recognized as a gray calcareous shale a more or less mottled appearance from the presence of ımbers of Foraminifera, and occasionally included bands ιy limestone.

ughout the greater portion of the area it does not exhibit any very great thickness, generally ranging from 100 to 150 feet. In the Manitoba Oil Co's bore on Vermilion River it appears to have a thickness of 130 feet. Its total thickness is very rarely seen, but on North Pine Creek it is less than 400 feet and possibly is not half that thickness, while on Bell River on the eastern face of the Porcupine Mountain it is probably less than 250 feet. In the Swan River Valley, however, a total thickness of 470 feet in all was seen, and it is not improbable that the lowest 70 feet was not seen, giving for this locality a total thickness of 540 feet; the strata are very nearly or quite horizontal, and this must be regarded as a local thickening of the formation.

Grading upward from the top of the Niobrara Group, the Pierre shales are seen to occupy the summits of all the higher lands of the Riding, Duck and Porcupine Mountains. In the Riding Mountain and farther south the Pierre is found to be moderately well marked off into two subdivisions. The lower subdivision, which for convenience may be designated the *Millwood Series*, is composed of dark gray soft clay shales very similar to those already described by Dr. Dawson, Mr. M'Connell and the writer from Alberta and Assiniboia. These beds are well shown at the village of Millwood on the Assiniboine River close to the crossing of the Manitoba and Northwestern Railway, and here as elsewhere they include a considerable number of septarian nodules of ferruginous limestone. These nodules hold many beautiful specimens of typical Pierre fossils, such as *Scaphites nodosus* var. *quadrangularis*, *Lucina occidentalis*, *Baculites compressus*, *Pteria linguiformis*, *Inoceramus tenuilineatus*, *I. Sagensis* var. *Nebrascensis*, *Nucula* sp., *Entalis paupercula*, *Dentalium gracile?* *elytron* of a small beetle, and fragments of *scales of fishes* and *tests of crustaceans*. Professor H. Y. Hind has also recorded, probably from this series, *Anomia Flemingi*, *Inoceramus Canadensis*, *Leda Hindi*, *Lunatia obliquata*, *Cinulea concinna*, and an undetermined species of *Ammonite*.

On the face of the Duck and Porcupine Mountains in the valleys of North Pine and Bell Rivers, a dark gray clay shale is exposed about the base of this series, which also contains a large number of beautifully preserved Radiolaria, chiefly of the genera *Dictyomitra* and *Sethocapsa?* the former genus being represented by *D. multicostata* Zittel, described from the chalk of Brunswick.

These dark gray clay shales are overlain by a great thickness of light gray rather hard clay shales which are locally known as "slate," and which from their typical development at Odanah, near Minnedosa, on the Little Saskatchewan River may be called the *Odanah Series*. Throughout the series are many beds of septarian ironstone nodules, but very few of these nodules are compact like those in the Millwood Series, but are generally cut by numerous veins of crystalline calcite. No fossils were found by the writer in these shales.

The cliffs of this terrane generally weather with a more or less sloping surface, but in railway cuttings or by some streams where erosion is very rapid, they rise almost vertically, presenting a general lead-gray appearance. The beds are also much fissured, and iron-stains are everywhere seen along the lines of fissure. On a fresh surface the shale can be readily cut, but it quickly hardens on exposure to the atmosphere, and the streams cutting through it have their banks strewn with lenticular pebbles derived from it. In some places, as in the valley of the Little Saskatchewan River, alluvial beds of these pebbles are being used as ballast for the railway.

The Odanah Series is of considerable economic importance to the country, as, being very much fissured, it allows water to flow readily through it, and is thus the source from which many of the wells in western Manitoba obtain their supply of water. It is well shown west of the escarpment on both the Pembina and Riding Mountains, but probably on account of the paucity of sections, it has not yet been recognized farther north.

The whole thickness of the Pierre in Manitoba is about 1000 feet. The Millwood Series, as seen on the northern face of the Riding Mountain, has a thickness of between 450 and 500 feet, while about 300 feet of the overlying Odanah series is there also seen, reaching near to the summit of the mountain and being immediately overlain by the drift deposits. The top of the Odanah series is not seen in the Riding Mountain, but farther south Dr. Dawson gives the thickness of the upper portion of his Pembina Mountain group, which represents this series, as at least 300 feet.*

At the village of Deloraine in southwestern Manitoba and close to the northern face of the Turtle Mountain, the Tank-well on the Pembina Mountain branch of the Canadian Pacific Railway strikes the Odanah shales at a depth of about 90 feet, and a deep well close beside it does not strike the Niobrara till a depth of 1000 is reached, giving a thickness for the Pierre of 910 feet. At the foot of the Turtle Mountain a band of hard gray calcareous sandstone crops out in various places, and taking this to represent the base of the Laramie, though no fossils have as yet been recognized from it, the whole thickness of the Pierre would be given at a little more than 1000 feet. Considering the Millwood Series as having a thickness of 500 feet, a thickness of about 500 feet would remain for the Odanah Series.

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* Report on the Geology and Resources of the 49th Parallel, by G. M. Dawson. p. 85. Montreal: 1875.

The Laramie has nowhere been recognized in northwestern Manitoba, the Cretaceous being there immediately overlain by a great thickness of glacial and post-glacial deposits, and in southern Manitoba the only place from which it has been recorded is in Turtle Mountain,* and though the beds here have since been hastily examined, their thickness has not been determined. The sandstones of this terrane are associated with beds of lignite that will furnish valuable local sources of fuel-supply for Manitoba.

Ottawa, May 1st, 1890.

ART. XXX.—*On Mordenite*; by LOUIS V. PIRSSON.

UNDER the name of mordenite in 1864, How† published a description of a new zeolite, occurring at Morden and Peter's Point, Nova Scotia. To this species he assigned the general formula $RO, R_2O_3, (SiO_2)_9\ 6H_2O$. The correctness of this formula has long been considered doubtful, owing to the high ratio of silica to the bases and it is supposed that How analyzed a mixture of some zeolite with silica, more especially as his mineral did not occur in distinct crystals. It will therefore be of interest to announce the re-discovery of this interesting species in a new locality, to present a new analysis of pure material, proving the correctness of How's work, together with a discussion of its composition and a description of its crystal form and other physical properties.

The material upon which the present work is based I collected in October, 1889, while engaged in temporary field work on the Yellowstone Park division of the U. S. Geological Survey, in western Wyoming. The locality was one of the high points of the ridge running eastwardly from Hoodoo Mountain, and forming part of the divide between branches of Crandall Creek whose waters run into Clark's Fork and the head of the Lamar River or east fork of the Yellowstone. The locality is several miles from Hoodoo Mountain. The mordenite occurs lining the amygdaloidal cavities of a mass of decomposed basalt, one of the former inclusions in the basic breccia forming the ridge. At the time it was unfortunately supposed to be one of the commonly occurring zeolites and only a small specimen was secured. Recently, while examining some material obtained in that region, this specimen came to light and as some tests failed to classify it, a complete investigation was undertaken with the results here presented. In order to obtain enough material for analysis nearly the whole of the specimen had to be sacrificed. As the mordenite occurs in very small crystals, one of average size measuring under the microscope 1^{mm} in height and breadth by about $\cdot4^{mm}$ in thickness, it would have been impossible to pick out sufficient pure material for analysis.

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* Dr. Selwyn, on Boring Operations in the Souris Valley. Report of Progress, Geol. Survey of Canada, 1879-80, p. 11A.

† Journal of the Chemical Soc., II, ii, p. 100, 1864.

A preliminary specific gravity determination showed it to be about 2·14 and it was therefore determined to separate it by means of the Thoulet solution, it being so much lighter than the pyroxene and other minerals that might be expected in the basalt. The specimen was therefore crushed fine enough to pass through an 80 mesh sieve, washed free from dust and twice separated by the Thoulet solution. In the last operation the mordenite floated on a solution of 2·179, and sank when the density was lowered to 2·119. Its specific gravity is therefore between these two determinations. The density of the Thoulet solution was taken with a Westphal balance.

The material thus obtained after washing and drying, proved on examination under the microscope, to be of exceptional purity, consisting wholly of crystal fragments, showing characteristic outlines and cleavage, and with no adherent particles of any foreign substance. The greater part were perfectly transparent and colorless, occasional fragments showed a very pale brownish discoloration in spots, as if due to the infiltration and deposition of a minute amount of iron ore or organic matter into cleavage cracks. In no respect as to appearance or their action on polarized light did these latter differ from the colorless pieces.

A test was again made with the Thoulet solution to ascertain if any difference in specific gravity could be found between the two. Very careful testing failed to show any whatever. Both floated and sank at precisely the same densities and in precisely the same proportion. Great confidence is therefore felt in the purity of the material operated upon. The perfect separation by the Thoulet solution was no doubt due to the heavy, crumbly nature of the basalt with which the mordenite was associated and its own brittleness and low specific gravity. By this means about one gram of the pure mineral was obtained. It was thoroughly washed and dried at about 70° F. It was then finely powdered and subjected to analysis. A preliminary test showed that the mineral was scarcely attacked by boiling hydrochloric acid. The material was therefore divided into two equal portions and in the first, which was brought into solution by a mixture of sulphuric and hydrofluoric acids, everything was determined except the silica. The second portion was subjected to a sodium carbonate fusion and everything determined save the alkalies.

The water was first determined in both portions by ignition. It was given up and the weight became constant at a moderate red heat. Before determining the water in No. I, it was found that the powdered mineral lost about 3·6 per cent of water by one hour's exposure to a heat of 100° C. The process for determining magnesia and the alkalies was as follows. After separating in No. I, the alumina and ferric oxides by ammonia and the lime by ammonium oxalate, the filtrate was evaporated and ignited gently in a platinum dish until all ammonium salts were driven off. The residue was then dissolved in a little water, and a roughly estimated amount of previously purified barium hydroxide added. By this means all the sulphuric acid and magnesia present were thrown down and the alkalies obtained in the filtrate in a form suitable for conversion into chlorides and for determination, after the excess of barium hydroxide had been removed by ammonium carbonate. The trace of magnesia was then easily separated from the precipitate of barium sulphate by hydrochloric acid, filtered off and determined.

The analysis was at all points carried on both as a qualitative as well as a quantitative one. It yielded the following results.

	I.	II.	Mean.	Ratio.		
SiO_2	....	66·40	66·40	1·106	1·106	9·00
Al_2O_3	11·32	11·01	11·17	·1084	·112	·91
Fe_2O_3	·62	·52	·57	·0036		
CaO	1·89	1·98	1·94	·0346	·113	·92
MgO	·20	·14	·17	·0042		
K_2O	3·58	....	3·58	·0379		
Na_2O	2·27	....	2·27	·0366		
H_2O	13·31	13·31	13·31	·7394	·7394	6·01
Total,	....	....	99·41			

From these ratios it will be seen that the mineral agrees closely with How's general formula RO, $Al_2O_3(SiO_2)_9 6H_2O$ and if the slight amount of magnesia is taken as replacing lime it is evident that the protoxide bases are CaO : Na_2O : K_2O :: 1 : 1 : 1. The composition is then ($\frac{1}{3}K_2O$, $\frac{1}{3}Na_2O$, $\frac{1}{3}$CaO) Al_2O_3 $(SiO_2)_9$ $6H_2O$. In the type of mordenite analyzed by How there was only a slight trace of potash, and his composition showed ($\frac{1}{3}Na_2O$, $\frac{2}{3}$CaO) Al_2O_3 $(SiO_2)_9$ $6H_2O$ and in the present mineral one molecule of K_2O replaces one of CaO in How's type. The ratios show a slight deficiency of the bases. For the sake of comparison we give below the theoretical percentages calcuted for this formula and also present How's analysis and eory.

	Mean %.	Theory.	How %.	Theory.
SiO_2	66·40	65·72	68·40	66·73
Al_2O_3 (Fe_2O_3)	11·74	12·53	12·77	12·74
CaO (MgO)	2·11	2·27	3·46	4·62
K_2O	3·58	3·82	----	----
Na_2O	2·27	2·52	2·35	2·56
H_2O	13·31	13·14	13·02	13·35
Totals,	99·41	100·00	100·00	100·00

If, instead of accepting How's formula we take the ratio of e bases to the silica as found by my analysis, it will be seen at they give with remarkable exactness $RO : Al_2O_3 : SiO_2 : H_2O$ 1 : 1 : 10 : 6⅔. The formula becomes in this case (⅓K_2O, Na$_2$O, ⅓CaO) Al_2O_3 $(SiO_2)_{10}$ 6⅔H_2O. This becomes in genal $3RAl_2Si_{10}O_{24}+20H_2O$, the three Rs being replaced by a olecule each of potash, soda and lime.

In 1886, under the name of ptilolite, Cross and Eakins* decribed a new zeolite from Jefferson Co., Colorado, which, ke the mordenite, occurs as a secondary formation in a basic va. As the result of their investigations they assigned to the ineral the general formula $RAl_2Si_{10}O_{24}+5H_2O$, in which R nsisted of lime, potash and soda, not however in any simple tio. The similarity of these two formulæ is very striking, d it seems evident that the two minerals belong to the same oup of zeolites, the ratio of bases and silica being the same each, the chief difference being that the ptilolite contains e-quarter less of water. In the crystal form and optical operties, however, the two zeolites are entirely unlike.

While this formula for mordenite confirms the work of oss and Eakins in the existence of these very acid hydrous icates, which can no longer remain doubtful, and the theotical percentages calculated for it agree with very great seness with the given analysis, it will be best, however, to tain the composition given by How on account of its greater nplicity and because it differs but slightly from the above.

In the symmetry of its crystal form mordenite is monoclinic d also isomorphous with heulandite. The crystal habit is own in the figure and is remarkably similar to heulandite m Jones' Falls, near Baltimore, Md. The only forms served were *c*, 001, O; *b*, 010, $i\text{-}\grave{i}$; *l*, 450, $\grave{i}\text{-}\frac{5}{4}$; *t*, 201, $-2\text{-}\bar{i}$, d *s*, 20$\bar{1}$, 2-$\bar{i}$. The measurements were made on a Fuess niometer, using the δ ocular of Websky. From the small e of the crystals and poor reflections, owing to dullness of the faces and to striations due to a repetition of the crystal form in parallel position, a considerable series had to be examined before any sharp reflections could be obtained. No sharp reflections could be obtained from any clino-pinacoid, since from the separation of cleavage plates it was invariably too rough to reflect well. Finally one crystal was found which gave very fair and distinct reflections in the prismatic zone and from the orthodomes. Another gave good reflections in the zone of symmetry. From these the following (supplementary) angles were taken as fundamental:

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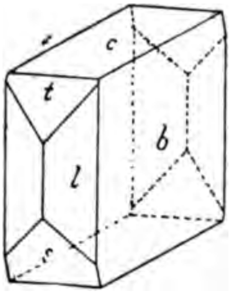
* This Journal, vol. xxxii, pp. 117, 1886.



$$c \wedge t = 001 \wedge 201 = 63° \, 40'$$
$$t \wedge s = 201 \wedge 20\bar{1} = 50 \;\; 12$$
$$s \wedge l = 20\bar{1} \wedge 450 = 36 \;\; 07$$

and from these we calculate the axial ratios

$$a : b : c :: \cdot 40101 : 1 : \cdot 42623, \text{ angle } \beta = 88° \; 30\tfrac{1}{2}' ;$$

and for heulandite we have,

$$a : b : c :: \cdot 40347 : 1 : \cdot 42929, \text{ angle } \beta = 88° \; 34\tfrac{1}{2}' ;$$

adopting the orientation given the latter species by Des Cloizeaux. Only one other satisfactory measurement could be made:

	Calculated.	Measured.
$l \wedge l = 450 \wedge 4\bar{5}0$	$= 53° \; 15'$	52° 44′ 52° 33′.

The only difference then between the mordenite and the Jones' Falls crystals of heulandite is that the prism occurring on the latter if taken as I (110) requires the similar prism on the mordenite to be (450) $i\text{–}\tfrac{5}{4}$.

The crystals occur attached at one end upon their prismatic faces. They form groups from growth parallel to the clino-pinacoid and are also somewhat radially disposed. The cleavage is eminently clino-diagonal and the luster of the clino-pinacoid is pearly, so that cleavage fragments resemble small nacreous fish scales. Under the polarizing microscope, using cleavage plates of the mineral which furnish sections parallel to the clino-pinacoid, it was found that the plane of the optic axes is normal to this face. The direction of extinction is negative, according to the scheme adopted for the plagioclase feldspars and inclined about 15° to the clino-diagonal axis. This axis of elasticity = $\mathfrak{c}$ and $\bar{b} = \mathfrak{a}$. The optic angle is large and it is uncertain whether $\mathfrak{c}$ or $\mathfrak{a}$ is the acute bisectrix; the double refraction is weak, high polarization colors being shown only by the thickest sections between crossed nicols, while thin sections show gray of the first order. The hardness of mordenite is about 3. How gives 5 for his mineral. While it is difficult to ascertain the exact hardness of a species occurring in such small brittle crystals it was certainly not so hard as 5, and 3 is believed to be more correct. Before the blow-pipe mordenite does not exfoliate; it gives off its water readily, practically without changing its form, and melts with some difficulty to a white enamel.

The writer desires at this place to express his obligations to Mr. Arnold Hague of the U. S. Geological Survey, to whose kindness the collection of this mineral was due, and to Prof. S. L. Penfield for valuable assistance and advice.

Mineralogical Laboratory, Sheffield Scientific School, April 14th, 1890.

ART. XXXI.—*Geology of Mon Louis Island, Mobile Bay*;

by DANIEL W. LANGDON, JR.

IN 1855 Tuomey* was handed some fossiliferous, ferruginous sandstone from the western shore of Mobile Bay, containing impressions of *Cardium magnum*, *Ostrea Virginica* and a *Modiola* resembling *M. demissa*, but was unable to fix definitely the locality. In 1885 Dr. Geo. H. Taylor, of Mobile, gave the writer a small box of shells obtained from the mud dredged in the channel of Mobile Bay, some ten miles from the Gulf. From their physical appearance they were supposed to be fossil —perhaps Pliocene or even Miocene, and with the idea of establishing this fact they were submitted to Mr. T. H. Aldrich, of Blocton, Ala., who in turn forwarded them for identification to Mr. W. H. Dall, of the National Museum. Mr. Dall decided that they were recent shells now living in the deeper waters of the Gulf and probably washed in the bay by submarine currents. Some time later Dr. Taylor submitted another lot of shells contained in the same matrix, an impalpable blue mud, and said to have been found on the Mon Louis Island, some fifteen miles below Mobile. A trip to the island proved its identity with Tuomey's locality, "Yellow Jack" being a creole patriarch whose descendants still inhabit Mon Louis. As was stated by Tuomey's informant, this fossiliferous stratum was found to be about three feet above mean tide, and was clearly the oxidized and lithified phase of the shell-bearing blue mud occurring at various elevations along the coast of the island to within about four miles of the Gulf, and found in the dredged channel of the Bay. These blue mud deposits are sometimes filled with shells, at others free from organic life, at times taking the form of extensive oyster beds, at others having more marine characteristics, containing *Natica duplicata*, *Arca transversa*, *Cardium magnum*, *Pecten* sp.?, et als.

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* 2d Bien. Report on Geol. of Ala., pp. 149–150, 1859.

Wells dug in the vicinity demonstrate the continuity of this bed inland, and Hilgard* has noted its occurrence farther westward. These wells reveal, too, a substratum of fetid black clay containing cypress logs, what seems to be the remains of a submerged cypress swamp. An interesting fact is that these same fetid clays have been encountered in wells dug in the suburbs of Mobile, but so far as the writer has been able to ascertain, the shell bed has never been found so far north.

Overlying these shell beds on Mon Louis Island and making the surface soil through south Mobile County are series of cross-bedded sands and loams usually very light colored and devoid of clay or pebble beds. These beds are about fifteen feet thick and are quite similar to the beds of sandy loam found in the western part of the city of Mobile. McGee* has determined these last named loams as belonging to his Appomattox group, and should his identification prove correct it would change the age of the Appomattox to a more recent date than he now seems to suppose.

It establishes, however, a further extension inland than that marked by the present coast line and a fluctuation in the elevation of the floor of the Gulf in post-Tertiary times, which fact is believed to have not been previously noted.

Cincinnati, O., June 30, 1890.

Art. XXXII.—*On Leptænisca, a new genus of Brachiopod from the Lower Helderberg group*; by Charles E. Beecher, Ph.D. (With Plate IX.)

The species which is here proposed as the type of a new genus has long been considered as belonging to *Leptæna*, and was thus described in 1859.† In general external appearance, both forms agree very closely, but on careful examination, some differences may be detected and a comparison of the internal features reveals marked distinctions which cannot be included within the limits of a single genus.

The probability of a needed separation was significantly indicated by Professor James Hall, in a reference to figures of this species published in the Report of the State Geologist for 1882,‡ where it was designated as *Leptæna?* (*sub-genus?*) *con-*

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* Agric. and Geol. of Miss., pp. 154–156, 1860.

† Pal. N. Y., vol. iii, p. 197, Pl. XVIII, fig. 2, 1859.

‡ Id. explanation of plate (xv), 46, figs. 30, 31, 1883.

ava Hall. Mr. J. M. Clarke has also called the writer's ttention to some of the peculiarities of this group, and to ne or more new and interesting associated species which he as recently discovered, and which are congeneric.

As the type species is among the rarer forms from the ower Helderberg strata, it is probable that lack of material as prevented any one from determining its principal characers. Up to this time, no dorsal valve has been described or llustrated, and the features of the ventral valve have not been onsidered of sufficient moment or determination to warrant separation from *Leptæna.*

The material studied by the writer comprises six specimens, hree of which are separate valves, one ventral and two dorsal. Also, the original types in the American Museum of Natural History in New York City have been examined, and it is now evident that we have enough knowledge of the species to remove it from *Leptæna*, and to draw some interesting comparisons with forms which hitherto have had no apparent relationship to it.

LEPTÆNISCA, gen. nov.

Shell concavo-convex, attached to foreign objects by calcareous cementation of the ventral beak. Valves articulated by teeth and sockets. Dorsal or socket valve (figures 4, 5) concave; interior with a broad, more or less defined, spiral impression on each side of the median line, making a single volution. Adductor impressions small. Cardinal line narrow, bearing in the center two prominent, bilobed, cardinal processes, separated to admit the vertical septum in the opposite beak (figures 2, 3).

Ventral valve (figure 1) convex, area elongate, triangular, fissure covered with a pedicle-sheath. Cardinal muscular scar supported on or limited by two elevated lamellæ. Cavity of beak divided by a vertical septum, on each side of which, in the anterior half, is a small adductor scar. Shell structure punctate. Type *Leptæna concava* Hall.

Besides the foregoing essential characters presented by the ype species, there are others which are mainly of specific inerest. Both valves are strongly papillose on the interior, and he dorsal has a low ridge within the margin, impressed by the ascular lines. The surface ornamentation consists of fine lternating interrupted radiating striæ, very closely resembling he sculpture of many species of *Leptæna.*

There appears to be little in common between this species nd *Leptæna* of the *L. transversalis* type, except in the articulaion of the valves, the punctate shell structure, and the general form and surface ornamentation. The more important internal characters, such as the cardinal muscular lamellæ, small dorsal adductor scars, spiral impressions, attached ventral valve, and cleft dorsal callosity, are incompatible with that genus as expressed by the species *Leptæna transversalis* Dalman.

The muscular scars and hinge characters are similar to the strophomenoid group, but on the other hand, the Productidæ possess many elements which find an expression in *Leptænisca*, and it is evidently genetically related to that family and may be considered as an ancestral form of *Strophalosia*.

With this view, the spiral markings on the interior of the dorsal valve represent the common reniform impressions of the Productidæ, and not true brachial impressions, such as occur in *Koninckina*. Compare figure 5 with typical *Strophalosia* represented in figures 6 and 16.

Yale University Museum, May 1st, 1890.

ART. XXXIII.—*North American Species of Strophalosia*; by CHARLES E. BEECHER, Ph.D. (With Plate IX).

THE little shells described in this paper from Carboniferous and Devonian formations of North America are always found attached to some other organism, and none have yet been noted which reach the size and spinoseness of their Permian congeners. They were evidently derived from free ancestral forms, as they all exhibit a pedicle-sheath, although from their habit of fixation a pedicle would be functionally useless. It is natural to suppose, however, that in their extremely early stages, the shells were unattached, and simply anchored by a pedicle, as in ordinary brachiopods, and after a brief free existence, they fixed themselves to some foreign object by their tubular spines, and by calcareous cementation of the ventral valve. In many cases the specimens are found gregarious, as many as twelve having been seen on the shell of a single gastropod, which itself was commensal with a crinoid (see fig. 24).

The first specimens discovered by the writer were found upon individuals of *Platyceras equilaterale* Hall; among some collections made by Professor F. H. Bradley and Rev. D. A. Bassett, from the Keokuk shales, at Crawfordsville, Indiana.

Subsequent search resulted in determining that the species described as *Crania radicans* Winchell, belonged to the genus *Strophalosia*. Soon after this, Mr. Charles Schuchert kindly called my attention to a third and minute species, which he had discovered among some specimens of larger brachiopods, collected by Mr. R. R. Rowley from the Choteau limestone of

Missouri. Besides these three species, others from various formations have been described and referred to different genera which, it is believed, will eventually be included under *Strophalosia*, and others thus determined may ultimately be placed elsewhere. Several will require the reëxamination of the type specimens, and the study of additional material, before any fixed conclusions can be reached, so that they will be but briefly noticed in this place.

Productella truncata Hall,[*] from the Marcellus shale, uniformly shows a truncation or cicatrix of the ventral beak, indicating an early condition of attachment which is very suggestive of *Strophalosia*. This relationship was recognized by Professor Hall in 1857 (loc. cit.), where he says in some general remarks on the "Producti of the Hamilton and Chemung groups:" "Among these are several forms which externally have the form of *Strophalosia*." J. F. Whiteaves, F.G.S.,[†] recently again recognized these relations, and refers to the species as *Productella* (*Strophalosia?*) *truncata*. He also illustrates a specimen of *Strophalosia productoides* Murchison, from the Devonian (Hamilton) rocks on the Athabasca River, identified by Thomas Davidson, and this, so far as known, is the first unqualified recognition of the genus in North America. *Chonetes muricatus* Hall,[‡] offers about the same amount of evidence as *Productella truncata*, and may tentatively be placed with *Strophalosia*.

Dr. Shumard in 1858[§] described a species from the Permian of Texas as *Aulosteges Guadalupensis*, and in a subsequent paper in the same volume, he again refers to it as *Strophalosia* (*Aulosteges*) *Guadalupensis*, giving two figures in illustration. The writer is unable, either from the figures or description, to express any definite opinion as to its generic relations, and doubts whether it will go into either of the two genera mentioned.

In 1864, Professor Winchell provisionally referred a species to *Strophalosia*[‖] with the specific name of *nummularis*, which apparently belongs to this genus or to *Productus*. In this instance, again, further examination of specimens is requisite.

The principal object of these citations is to call attention to the species which have been referred to *Strophalosia*, and to suggest others which may ultimately go with it. The two following species yield more positive evidence: *Crania radicans* Winchell* and *Aulosteges spondyliformis* White and St. John.†

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[*] Tenth Ann. Rept. N. Y. State Cab. Nat. Hist., p. 151, 1857.

[†] Contributions to Canadian Palæontology, vol. i, pt. II, p. 112, 1889.

[‡] Pal. N. Y., vol. iv, p. 142, 1867.

[§] Transactions of the St. Louis Academy of Science, vol. i, p. 292, 1858.

[‖] Proc. Acad. Nat. Sci. Philadelphia, vol. xv, p. 4, 1864.

The first is here illustrated by figures 14–17, Plate IX, and is seen to agree with typical Strophalosia in every essential feature. The second (*Aulosteges spondyliformis*), from the Upper Coal Measures of Iowa, in many respects, resembles the species here described from the Keokuk, but in general form it is more like the European Permian types. The authors give the accompanying description, which well expresses the characters in accord with *Strophalosia.*

"Shell minute, parasitic, subtriangular in outline, greatest width near the front margin; posterior half of the lateral margins straight; front broadly rounded, and slightly emarginate. Ventral valve not very deep, attached to foreign objects by its spines, which are numerous and rather long; area not quite so high as wide, retreating from the hinge line towards the beak; pseudodeltidium small and not very prominent."

"Dorsal valve slightly concave, a little more so toward the front margin; surface marked by somewhat prominent concentric lines of growth, having always fewer spines than that of the ventral valve, and sometimes none."

The number of spines shown in the specimen figured by them is eleven, and attention is called to the fact that the specimens were found attached to *Chætetes* and *Campophyllum.*

From present information, therefore, the genus *Strophalosia* may be considered as having the following American species, some of which, however, are doubtfully included.

Strophalosia radicans Winchell. Hamilton group.
Strophalosia productoides Murchison. Hamilton group.
Strophalosia scintilla Beecher. Choteau limestone.
Strophalosia Keokuk Beecher. Keokuk group.
Strophalosia spondyliformis White and St. John. Upper Coal Measures.
Strophalosia truncata Hall. Marcellus shale.
Strophalosia ? muricata Hall. Chemung group.
Strophalosia ? nummulina Winchell. Marshall group.
Strophalosia ? Guadalupensis Shumard. Permian.

Several original illustrations of typical Permian species are introduced on Plate IX for the purpose of comparison both with the American *Strophalosia*, and with the genus *Leptænisca.*

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* Rept. Lower Peninsula Mich., p. 92, 1866.

† Trans. Chicago Acad. Sci., vol. i, p. 118, 1868.

Descriptions of Species.

phalosia radicans Winchell, sp. (Plate IX, figures 14–17).

broadly elliptical, or ovate, wider than long; greatest near the middle. Ventral valve conforming to the sur- f attachment, except at the elevated and free edges, are usually furnished with from ten to twenty tubular extending downwards and adhering to the object of n; hinge with two strongly developed, slightly oblique, al teeth; cardinal muscular impressions small, separated light ridge or septum. Dorsal valve convex at the beak, concave below, marked by lamellose concentric lines of h, and by a row of oblique wrinkles along the cardinal interior with a conspicuous, narrow, and elongate bifid al process extending beyond the hinge, and with deep sockets on each side; adductor muscular scars well de- septum only developed in the central portion of the reniform impressions distinct, enclosing a comparatively and strongly pustulose area.

ventral valve has a width, excluding spines of $7{\cdot}5^{\mathrm{mm}}$, length of $5{\cdot}5^{\mathrm{mm}}$. The dorsal valve, figure 16, measures width and 5^{mm} in length.

en well preserved, the spines are very rugose, and have the appearance of a minute annelid tube, as represented re 17. They often extend 4^{mm} beyond the edge of the but are not so numerous nor so elongate as in *S. Keokuk.* small ventral valve, growing in a cavity in the epitheca oral, is attached only by the beak, and by spines from the al margin. The remainder of the valve is free, and the form is very convex, with the surface marked by irregu- mellose striæ and by infrequent short spines, which e stronger and more elongate near the surface of attach-

logical position.—Shales of the Hamilton group, on spe- s of *Acervularia Davidsoni* E. and H., and *Zaphrentis rsensis* Winchell, Little Traverse Bay, Michigan. Pre- l to Yale University Museum by Professor Alexander hell.

Strophalosia scintilla sp. nov. (Plate IX, 10–13).

ll minute, broadly ovate, widest across the middle. Dor- lve convex at the beak, flat or concave below; beak in- icuous; interior with small adductor muscular scars; pus- near the margins; reniform impressions not defined in ingle interior of this valve observed. Ventral valve ted to foreign objects; margin elevated and usually hed with a variable number of short procumbent slender , not exceeding six in the specimens examined; hinge a little shorter than the width of the shell, with a narrow triangular central fissure, covered by a pedicle-sheath; teeth well-developed; cardinal muscular scars small, obscure, confined to the umbonal cavity.

A specimen of medium size measures 2·6^{mm} in width, and 1·6^{mm} in length.

Some examples, as in figure 11, are without marginal spines, and none have shown them developed along the hinge, as is characteristic of the other species here described. All the individuals observed have been found attached to larger forms of brachiopods of the genera *Productella*, *Spirifer*, *Syringothyris*, and *Cyrtina*.

Geological position.—From the Choteau limestone, Pike County, Missouri. Collected by R. R. Rowley, and loaned to the writer by Charles Schuchert.

Strophalosia Keokuk sp. nov. (Plate IX, figures 18–24).

Shell broadly elliptical or ovate, truncate along the hinge, greatest width usually near the middle of the length. Ventral valve attached by its central portion; margins furnished with numerous, often crowded, spines serving as additional points of attachment to foreign objects; area triangular, with a narrow fissure covered by the pedicle-sheath; cardinal teeth well-developed; muscular scars faintly defined and separated by an obscure median septum; interior finely pustulose and marked about the margins by openings leading into the tubular spines. Dorsal valve concave, convex on the umbo and beak; surface smooth or marked by a few concentric wrinkles; cardinal process present; interior not observed.

The largest specimen observed has a width of 11^{mm}, and an individual of average size measures 6·5^{mm} in width and 4·8^{mm} in length.

All the specimens which have thus far been found are on shells of *Platyceras*. Many of the latter were attached to the tegmina of crinoids, as they frequently occur at Crawfordsville, Indiana. In a collection comprising about two hundred *Platyceras*, twenty were found supporting *Strophalosia*, and sixty-seven valves of this genus were observed on these specimens.

Mr. Charles Schuchert has called the writer's attention to a specimen of *Productus horridus* Sow., on which are one mature and eight young individuals of *Strophalosia Goldfussi* Münster. The larval shells bear a very close resemblance to the specimens of *S. Keokuk* here described, and in their early stages of growth both species are indistinguishable from each other. *S. Goldfussi*, however, develops spines on the dorsal valve at an early period, while none have yet been seen on specimens of *S. Keokuk*.

Geological position.—In the Keokuk shales at Crawfordsville, Indiana. Collected by Professor F. H. Bradley and Rev. D. A. Bassett.

Yale University Museum, May 27th, 1890.

EXPLANATION OF PLATE IX.

Leptænisca concava, Hall, sp.

Figure 1.—Ventral valve, interior; showing cardinal area and teeth; cardinal muscular lamellæ,; adductor impressions, *a*; vertical septum. Natural size.

Figure 2.—Posterior view of dorsal cardinal process. x 3.

Figure 3.—The same; seen from above. x 3.

Figure 4.—Dorsal valve; side view in outline. x 3.

Figure 5.—Dorsal valve, interior: showing cardinal processes, dental sockets, adductor muscular scars, median ridge, and spiral impressions. Natural size. Lower Helderberg group, Clarksville, N. Y.

Strophalosia excavata, Geinitz.

Figure 6.—Dorsal side of internal mould; showing muscular scars, septum, and reniform impressions. Natural size.

Figure 7.—Ventral view of another specimen, showing the adductor scars. Natural size.

Figure 8.—Profile of same. Natural size. Permian, Poesneck, Germany.

Strophalosia Goldfussi, Munster.

Figure 9.—Internal mould of ventral valve: showing cardinal and adductor muscular scars, and vascular lines. Natural size. Permian, Trebnitz, Germany.

Strophalosia scintilla, Beecher.

Figure 10.—Specimen adhering to ventral valve of *Productella pyxidata*, Hall. Natural size.

Figure 11.—Specimen showing no spines; growing on *Spirifer Marionensis*, Shumard. x 6.

Figure 12.—Specimen showing four spines; on *Productella pyxidata*, Hall x 6.

Figure 13.—Interior of ventral valve, on *Syringothyris sp.*; showing cardinal muscular scars, hinge area, teeth and six marginal spines. x 6. Choteau limestone, Pike County, Missouri.

Strophalosia radicans, Winchell, sp.

Figure 14.—Interiors of two ventral valves; showing hinge-teeth and spines. x 2. Specimens of *Spirorbis* became attached after death of *Strophalosia*.

Figure 15.—Specimen preserving dorsal valve; showing cardinal wrinkles. x 2.

Figure 16.—Interior of dorsal valve; showing adductor muscular scars, reniform impressions, cardinal process, and dental sockets. x 2.

Figure 17.—Spine enlarged to 10 diameters. Hamilton group, Little Traverse Bay, Michigan. Specimens figured, growing on *Acervularia Davidsoni*, E. and H.

Strophalosia Keokuk, Beecher.

Figure 18.—Interior of imperfect ventral valve showing muscular scars, septum and numerous long slender marginal spines. x 2.

Figure 19.—Small specimen preserving dorsal valve. x 2.

Figure 20.—Profile of same. x 2.

FIGURE 21.—Cardinal view of ventral valve, from right side of specimen figure 22. x 2.

FIGURE 22.—Interiors of two ventral valves. Left specimen shows septum and muscular scars. Center of right hand valve has been removed, exposing shell of *Platyceras*. x 2.

FIGURE 23.—Cardinal view of specimen, showing pedicle-sheath, dorsal callosity, hinge area and numerous spines. x 2.

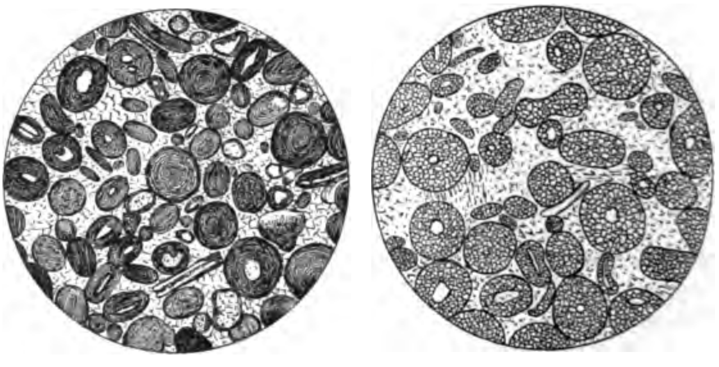
FIGURE 24.—Shell of *Platyceras equilaterale*, H., on tegmen of *Ollacrinus tuberosus* (not represented) showing numerous attached specimens of this species in various conditions and stages of growth. Natural size. Keokuk group. Crawfordsville, Indiana.

ART. XXXIV.—*Notes on the Microscopic Structure of Oolite, with analyses;* by ERWIN H. BARBOUR and JOSEPH TORREY, JR.

WHILE making notes the past autumn and winter preparatory to a thorough study of the oolite of Iowa, several points were noted which seemed to the writers to be of sufficient interest to be presented here. Ordinary oolite occurs in this State in deposits of considerable extent, but it is not proposed at this time to do more than to describe the microscopic structures and to give analyses of two forms. The following are analyses of two varieties of the Iowa river oolite:

1. *Oolite with concretionary structure.*	
Silica	2·10
Oxide of aluminium	3·20
Oxide of iron	
Calcium carbonate	85·99
Magnesium carbonate	8·52
	99·81
Specific gravity	2·619

2. *Oolite with brecciated granules.*	
Silica	4·56
Oxide of aluminium	3·40
Oxide of iron	
Calcium carbonate	84·33
Magnesium carbonate	7·50
	99·79
Specific gravity	2·632


1. 2.

Figs. 1, 2.—Micro-sections of Iowa River Oolite; magnified 10 diameters. *1. Showing* concretionary structure. 2. Showing granular structure of spherules.

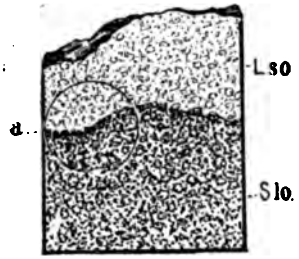
The kind shown in fig. 1 is the familiar concentric type, the other, shown in fig. 2, illustrates one with a sort of brecciated spherule, each being composed of a mosaic of exceedingly small fragments cemented together about a center. Though differing so widely under the microscope, these two are essentially alike, showing only slight external and chemical differences. Other aspects of these and other specimens will be fully considered at another time.

While examining these specimens, a *siliceous* oolite was received from eastern Pennsylvania, which merits description. Popularly the name oolite presupposes a calcareous rock, yet we have at hand several characteristic oolites which are not calcareous; these include an iron-oxide form, a strictly siliceous kind, a silica-lime, and a lime-silica form. The last two seem to be transitional forms between the true lime or calcareous oolite on the one hand and the siliceous on the other. In the siliceous oolite the roe and matrix are so intimately united, both being nearly pure silica, that the conchoidal fractures, in the denser sorts, pass alike through spheres and cement, as if it were a homogeneous quartzite. In the more friable sorts the concretions pull away intact from the matrix, and present to the eye the familiar fish-roe appearance of oolite proper, for which it could easily be mistaken by a careless observer. A second glance, however, reveals certain superficial differences, in hardness, color, etc. In the siliceous oolite, the concretions—which are noticeably uniform in size and spherical in form—are considerably darker than the surrounding matrix, being almost black in some specimens. On the other hand, those in the true oolite are generally of a much lighter color than the calcareous cement. A fractured surface of the siliceous variety exposes the component spherules in section, showing their concretionary structure—their concentric coats of alternately lighter and darker color, deposited around real or imaginary centers. In many, organic remains are the nuclei; in others, crystals or fragments of inorganic matter.

A polished surface of this oolite slightly etched with hydrofluoric acid shows to perfection these agatized bands; and a microscopic section brings them out to still greater advantage. In such a section, under a low power, it is interesting to notice the numerous rings of various widths and colors arranged around their respective centers, and to further observe how this concentric arrangement continues on into the matrix of the interstices not unlike the coast lines on a map. Often the interspaces are filled with aggregations of minute spherules (not visible to the eye), which also show concentric rings (see figs. 5 and 6). In several instances, lines of faults run through the specimens, pulling the spherules apart, displacing and distorting them in an interesting manner.

One of our most suggestive specimens of this oolite—an intermediate form between the lime and the siliceous varieties—shows two distinct bands, marked by a strong dividing line line (see fig. 4).

3



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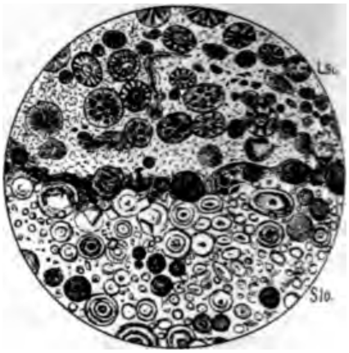


Fig. 3.—Portion from which the micro-section of fig. 4 was cut, at *a*. Fig. 4.—Pennsylvania Oolite, Lso, Lime-Silica Oolite; Slo, Silica-Lime Oolite magnified ten diameters.

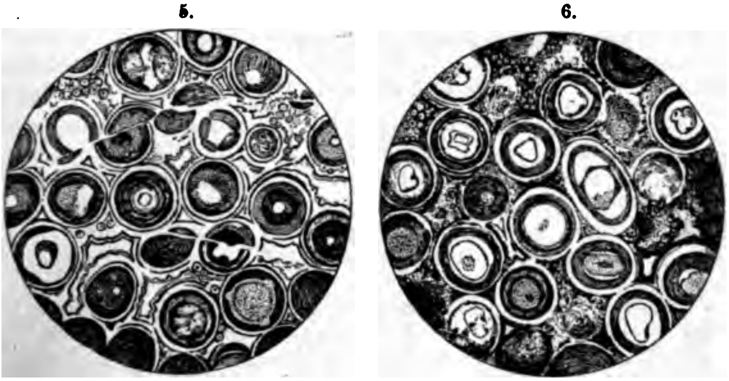
Analysis of Lime-Silica Oolite (Lso).

Silica	3·70
Oxide of aluminium Oxide of iron	1·42
Calcium carbonate	88·71
Magnesium carbonate	8·09
	100·92
Specific gravity	2·654

Analysis of Silica-Lime Oolite (Slo).

Silica	56·50
Oxide of aluminium Oxide of iron	1·50
Calcium carbonate	16·84
Magnesium carbonate	2·60
Water	12·54
	99·88
Specific gravity	2·688

One band is a lime-silica oolite, the other, a silica-lime oolite. The microscopic section of this piece shows the two bands plainly (see fig. 4). The lime-silica band is distinguished by spherules having a marked radiate structure. Crossing the dark dividing line of granules, we find the silica-lime band characterized by a lighter color, and by spherules having the concentric structure, interspersed with occasional radiate stragglers. While there are indications of a different mode of formation, it seems probable that the siliceous oolite is derived from the calcareous by the replacement of lime particles by silica.



Figs. 5 and 6.—Micro-sections of Siliceous Oolite from Pennsylvania, magnified 10 diameters.

The following is an analysis of the siliceous oolite:

Siliceous Oolite.

Silica	95·83
Oxide of aluminium Oxide of iron	2·93
Lime	1·93
Magnesia	trace
	100·69
Specific gravity	2·63

Single granule from Pennsylvania Siliceous Oplite.

Silica	99·99
Iron	00·01
	100·00

Single granule from the Iowa River Oolite.

Silica	2·54
Iron	trace
Calcium carbonate	97·44
	99·98

These interesting specimens of siliceous oolite were sent us by Mr. George R. Wieland of State College, Center Co., Pa. Two miles west of this place there are three or four square miles of light sandy soil, mostly uncleared, hence called the "Barrens," where this oolite, associated with flint, occurs scattered about in the form of surface bowlders weighing as much as 400 pounds. The fact that these masses of siliceous oolite are stained with iron oxide, and that they occur in an isolated spot, may account for their having escaped more general notice hitherto. It is said to occur also about fifteen miles northwest of College Centre.

Iowa College, Department of Geology and Chemistry,
April 2, 1890.

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *On a new Element occurring in Tellurium, Antimony and Copper, belonging to Mendeléeff's Eleventh Series.*—In consequence of a coincidence which he has observed between certain of the lines in the ultra-violet spectra of tellurium, antimony and copper, Grünwald argues the existence of a common impurity in these three elements In his opinion, the substance in question was originally present only in the tellurium, and that in the process of reducing the other elements from their ores, a portion of it has been transferred to these metals. On multiplication by $\frac{11}{10}$ several of the above mentioned coincident lines are transformed into lines belonging to the primary element "*b*" in the spectrum of water. In accordance with the principle laid down some time ago by the author, this fact indicates that the impurity spoken of consists, to a large extent at least, of an element occurring in the eleventh horizontal line in Mendeléeff's tables. The character of the spectrum itself shows that it cannot be any one of the known elements in that series. Hence Grünwald believes it to be an unknown element in the tellurium group with an approximate atomic mass of 212, probably identical with the austrium of Brauner. In general properties, therefore, it is an element closely resembling tellurium and also antimony and hence will be difficult to separate from these metals. On the assumption that copper is an alkali-metal of low melting point, the new element probably behaves in it as an electronegative constituent; and hence copper is ordinarily found combined with this difficultly-fusible and nonmetallic element.—*J. Chem. Soc.*, lviii, 434, May, 1890. G. F. B.

2. *On the Chlorides of the Compound Ammoniums.*—Le Bel has observed a new kind of physical isomerism occurring in the compound ammoniums. Assuming that the atoms or radicals in a substituted ammonia are capable of movement about the central nitrogen atom, and do not have fixed and definite relative positions, the existence of two isomeric derivatives may be imagined without introducing the hypothesis that they have been formed in different ways, such as by the union of RCl with NR', or of R'Cl with NRR'_2. A remarkable group of cubic salts, formed from chlorides of the type NRR'_2Cl, exists among the platinochlorides of the amines. To this group methyl-tripropyl-ammonium platinochloride and trimethyl-propyl-ammonium platinochloride belong, but the limit is passed by the trimethyl-isobutyl ammonium salt. As a rule if a platinochloride does not differ from the cubic salts by more than a single methyl-group, its crystalline form will be so nearly a cube that very careful goniometric and optical examination will be necessary to prove that it is not cubic. Trimethyl-isobutyl-ammonium platinochloride was first obtained in highly bi-refractive needles, distinctly not cubic; but on recrystallization octahedra were obtained, closely resembling regular octahedra

and permanent, i. e., not convertible into the prismatic form. On treating them with silver-oxide, neutralizing the filtrate with hydrochloric acid and evaporation, the hydrochloride was obtained partly in needles and partly in octahedra. Hence there are two hydrochlorides of this compound ammonium as there are two platinochlorides, the prismatic form of the hydrochloride being the more stable.—*C. R.*, cx, 144, 1890; *J. Chem. Soc.*, viii, 475, May, 1890. G. F. B.

3. *On the production of Ozone and the formation of Nitrites in Combustion.*—Ilosvay has confirmed the observation of Leeds that no ozone is formed by the action of concentrated sulphuric acid upon potassium permanganate, the supposed reaction of ozone being due to chlorine contained as an impurity in the permanganate, or even in the absence of chlorine, to the direct action of the promanganic oxide in the form of a violet vapor. With four or five grams of promanganate, the action proceeded satisfactorily. But on attempting to use 20 grams, a strong detonation resulted, due no doubt to the decomposition of the anhydride by the heat generated. Oxygen prepared by the action of concentrated sulphuric acid on potassium dichromate also contains no ozone.

The author has also explained the products of the combustion of coal gas under modified conditions. In one case the Bunsen flame was allowed to strike down, much air being mixed with the gas; in a second, carbon dioxide was admitted to the Bunsen flame; and in a third, a flame of air was obtained in the gas. The products of combustion were carried through a dilute solution of sodium hydroxide and the presence of nitrous acid was detected in four or five minutes in the first and second cases, and in 25 or 30 minutes in the third. Oxygen and nitrogen dioxide were then mixed with the air burning in the illuminating gas. The flame was more brilliant and cyanogen was observed among the products of the combustion. Since ammonia had also been observed among the products of the combustion of air in coal gas, the author regards these facts as proving the affinity of nitrogen at high temperatures for hydrogen and carbon as well as oxygen.

In other experiments the author observed the production of nitrites but not of ozone when air is passed over platinum heated to 200° to 300°. In the case of platinum gauze the action begins at 280° and continues up to 350°; but the property is lost after an hour and a half. With platinum black the action begins at 180°, reaches a maximum at 250° and diminishes above 300°. After repeating the experiment three or four times, the power of effecting the combination is lost. With platinum sponge, the action begins at 250° and is strongest at 300°; at 350° it becomes feeble and in three or four hours disappears entirely. Since the activity of the platinum when lost is not regained by heating in hydrogen, the author concludes that the loss of its power is due to a change in its molecular structure, and not to a condensation of nitrogen and oxygen on its surface. Moreover he has observed that nitrites are formed where air is passed over finely divided iron at about 200°; and that the resulting oxide when washed, yields these nitrites in appreciable quantity.—*Bull. Soc. Chem.* III, ii, 734, Dec., 1889. G. F. B.

II. GEOLOGY AND MINERALOGY.

1. *Clinton Group fossils with special reference to Collections from Indiana, Tennessee and Georgia;* by A. F. FOERSTE.—This report contains descriptions of a large number of species, many of them new, from localities in the States mentioned in the title, and comparisons with the distribution of the species in more eastern localities, with special reference to the condition at the time of the Cincinnati anticlinal axis. We have in it the first paleontological identification of the Clinton formation in Indiana on the west side of this axis.

After the descriptions the author makes a comparison of the Clinton fossils with regard to their distribution and states the following facts as to *species absent from the anticlinal.* These include *Leptocœlia hemispherica,* which is common east of the anticlinal from Anticosti to Tennessee and Alabama; *S. obscura,* from New York and Tennessee; *Cornulites Clintoni,* from New York to Alabama; *Illænus Ioxus,* from New York and doubtfully Alabama, yet known from the *Niagara* of Indiana and Wisconsin; *Ceraurus insignis,* from New York, and the Niagara of Wisconsin; *Homalonotus delphinocephalus,* from New York and Pennsylvania, and the Niagara of Indiana; *Dalmanites limulurus,* from New York and Pennsylvania, and in the Niagara of Ohio; *Calymene rostrata,* from New York and Georgia, and the Niagara of Indiana as *C. nasuta; Atrypa reticularis,* from Anticosti to Alabama, and the Niagara of Ohio, Indiana, Illinois and Wisconsin; and so with several other species not found on the anticlinal. In the remarks on these facts the author observes:

"Two suggestions may be offered as to the peculiar distribution of these forms in the Clinton. The first is that the fossils in question favored certain localities in the sea possibly those nearer the shore, and that these shore conditions did not occur at the anticlinal until at a later period. The extreme variability of shore conditions, however, implied by the character of the rocks farther eastward and the probability that parts of the anticlinal showed more shore action during the Clinton than did at least Anticosti, leaves, however, scarcely any margin for such a supposition.

The second is that the species in question may have been migrating toward the west at the time in question after the close of the break of the paleontological record, between the Upper and Lower Silurian periods, and that they did not reach the anticlinal until after the close of the Clinton period of that region. If this could be established by further observations it would be an interesting point in paleontological research. But if they migrated, where did the forms come from originally? As far as may be determined from the character and thickness of the rock deposits now remaining from that time, the land of the Clinton sea seems to have been nearest southeastern Pennsylvania, and thence to have curved around toward the Atlantic, both on the north and the south, perhaps more rapidly toward the north. This land, judging from the contributions it made to sedimentary strata, from the Clinton to the Upper Carboniferous periods must have had decidedly continental proportions. To our knowledge the sea deposits along the northwest of this paleozoic continent, at present represented in part at least by the deposits of Anticosti, was the only place showing comparatively no paleontological break between the Lower Silurian and the Clinton rocks and very likely was one of the sources from which certain of the Clinton fossils of the anticlinal came. The distribution of such forms as *Pleurotomaria* var. *occidens*, *Holopea obsoleta* var. *elevata* and *Spirifera rostellum* make it probable that such continuous breeding places for species existed also along the southwestern side of the paleozoic continent.

No doubt intermediate localities occurred of which we have no record and the position of which we cannot at present reconstruct. The very great range of many of the Clinton fossils, from Anticosti and New York to Alabama, while at a short distance off the line toward the westward they are absent for a time, or even permanently, make it probable that the species migrated north and south, comparatively freely in the shallower waters off the shore of the paleozoic continent, but that they found some physical obstacle in reaching the anticlinal. This obstacle was not land, since the well-borings of Ohio show that the Clinton is continuous between these two regions. Perhaps it was deep water which made the chances for migration over the short distance from the anticlinal to the Alleghany axis less satisfactory than the opportunities for migration for hundreds of miles along the western border of the old paleozoic continent.

That the anticlinal during the Clinton period was near land at least, seems probable from the occurrence of conglomerate in the southern exposures of the Clinton in Ohio. But what formations were then exposed, and where, seems not so certain. The pebbles from the Clinton of Ohio near Belfast in Highland county do not present recognizable remains in any of the specimens seen by us, nor is their lithological character such as to present positive evidence of any except their sedimentary origin. The cement binding the pebbles together contains very fresh specimens of *Cyclonema bilix* and well-preserved specimens of the so-called corals mentioned by the Ohio Geological Survey, but which are chiefly species of branched forms of *Ptilodictyæ: Ptilodictya famelicus*, *Ptilodictya rudis*, *Stictopora similis*, *Phænopora fimbriata* and *Phænopora magna*. *Cyathophyllum celator* var. *Daytonensis* was also found. Single specimens of *Orthis biforata*, with two plications in the mesial sinus. *Orthis elegantula* and a *Rynchonella* resembling *Rynchonella acinus* var. *convexa* were seen. All of the forms mentioned are common anticlinal Clinton forms.

The finding of the fossil tree, *Glyptodendron*, in the marine Clinton of Ohio, if authentic, would be only suggestive of the proximity of land, and the fact of its isolated occurrence would make a considerable distance from this land more than probable. Yet even if the existence of shallow water at the anticlinal be conceded, the existence of deep waters off the shore, between the anticlinal and the paleozoic continent on the east, can scarcely be proved at present. Yet for the present we suggest this view as a theory, perhaps to be compelled to withdraw it even ourselves should the proof to the contrary arise.

2. *Presidential Address before the Geological Society of London*, Feb., 1890.—Dr. BLANFORD discusses in his address the subject of the phenomena of ocean-basins. The arguments considered are (1) the supposed higher specific gravity of the earth's crust beneath the ocean, as inferred from pendulum observations, and the further inference that these areas of greater density have been the same since the original consolidation of the earth; (2) the absence with few exceptions of stratified rocks from the lands over the oceans, and the fact that nearly all these lands are volcanic; (3) the absence of deep-sea deposits in the rocks of continental areas; (4) the agreement between the distribution of plant and animal-life and the present arrangement of land-areas. Dr. Blanford's work in India, as Director of the Geological Survey, has supplied him with facts that give great interest to the discussion of the fourth of the above arguments, and the interest is enhanced by the contrast in cotemporaneous life between Europe and America on the one hand and India, Australia and South Africa on the other. We cite a paragraph bearing on this part of the subject:

"If, however, any geological evidence can be produced in favor of the view that the Indian Ocean, between India and South Africa, was bridged by land before either country was inhabited by placental, or perhaps by any, mammalia, it is, I think, clear that all the peculiar relationships of the Mascarene Islands would be satisfactorily explained. I think that the requisite geological evidence does exist. In the first place, attention must be called to the remarkable flora that extended from Australia to India and South Africa in Upper Palæozoic times. No doubt until very recently the principal European palæontologists refused to admit that this flora was Palæozoic, and even now the statement is occasionally made that the Carboniferous* flora of northern lands had a world-wide range. But the mass of evidence now available to show that the Newcastle flora of Australia and the Damuda Talchir flora of India are really Upper Palæozoic, despite the absence of European Palæozoic plants and the presence of what are, in Europe, Mesozoic types, is so clear that I feel sure any geologist who will examine the question will be convinced of its truth. In Australia the facts have long been perfectly well known, but in India they have only recently been fully cleared up, chiefly by the progress of discovery in the Salt Range of the Punjab. In South Africa the evidence is less perfect, though some important additions to our knowledge have resulted from Dr. Feistmantel's examination of the fossil plants, the account of which he has been so good as to send to me. In this account, which reached me only two days since, the representation of the peculiar Damuda flora of India in South Africa is shown to be beyond question, and much more complete than has hitherto been supposed.

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* Dr. Blanford adds, in a note, that in the following remarks, Carboniferous must be understood to include Permian.

"Now this flora is so strongly contrasted with the Carboniferous flora of Europe that it is difficult to conceive that the countries in which the two grew can have been in connection, and the hypothesis of Gondwána-land, as it is termed by Suess,[*] a great continent including Australia, India and South Africa, seems more in accordance with facts than Mr. Wallace's view that 'fragmentary evidence derived from such remote periods' is 'utterly inconclusive.'[†] For if each flora could be transported across the sea, why are no European Carboniferous plants found in the contemporaneous deposits of Gondwána-land and *vice versa.* Carboniferous plants of the European type are not confined to the northern hemisphere even, for they are found on the Zambesi in Africa and in Brazil. The accounts of their occurrence in Africa south of the Zambesi are as yet too indefinite for any clear idea of their relations to be formed, and it remains to be seen whether the *Lepidodendron* said to be found in Natal and the Transvaal is not Lower Carboniferous or Devonian, as in Australia."

Dr. Blanford does not mention the argument the writer has relied upon for evidence that continents were always continents and which he has presented in publications, including his Geology, for the past thirty-five years: That American geological history, that is, the progress in rock-formations and in mountain elevations through the successive periods, proves that there was through all a continued succession of continental conditions and changes, and thereby a uniform course of continental development. J. D. D.

3. *Paleozoic Fishes of North America*, by J. S. NEWBERRY. 228 pp. 4to, with 53 plates. U. S. Geol. Survey, Washington, 1889.—Prof. Newberry's new volume, besides reviewing to some extent the discoveries in the Paleozoic fishes of North America, hitherto reported by himself and others, gives full descriptions of many new specimens and species, and the author's final opinions on several debatable questions. The Pteraspids, *Palæaspis Americana* and *P. bitruncata*, discovered by Prof. Claypole in the upper member of the Onandaga Salt Group of Pennsylvania, are the only species of the Upper Silurian recognized as established. The earliest Devonian species are from the Oriskany sandstone of

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[*] Das Antlitz der Erde, Bd. i, p. 768.

[†] Island Life, p. 398, note.

Canada, north of Lake Erie, namely, spines of Machæracanthus and tuberculate plates probably of Macropetalichthys. With the Corniferous limestone, fishes begin to be well represented, 20 species having been thus far made out from the remains found in it; and they include one, probably, three Cephalaspids, a Coccosteus, and the earliest species of the remarkable genus Dinichthys of Newberry.

Speaking of the fishes of the following Devonian strata to the top of the Portage, the author states that recent discoveries have made known a closer relationship between Europe and America in the early Vertebrate fauna than had been supposed to exist, Canada having afforded species of Pterichthys, Cheirolepis, Phaneropleuron and Glyptolepis, and Germany, species of Dinichthys, Aspidichthys, Macropetalichthys and Machæracanthus. On the question of the relations of Pterichthys and Bothryolepis, he alludes to Prof. Cope's reference of Pterichthys to the Tunicates, and adds that "with abundant proofs of the relationship of Pterichthys to Bothriolepis, Aspidichthys, Holonema and the other Pterichthidæ, it is evident that they must be grouped together; the ichthyic character of Pterichthys is settled by the preservation in many instances of a tail covered with scales connected with the carapace."

From the "Cleveland Shale," which is made Carboniferous, and the lower member of the Waverly, 28 species of fishes are enumerated (including 2 of Titanichthys and 6 of Dinichthys); from the Carboniferous limestone, 347; and from the Carboniferous of Linton, Ohio, 27 species.

The plates illustrating this very valuable report bring out well the marvelous character of the early vertebrate fauna of America.

4. *Chert-beds of the Lower Silurian of Organic Origin.*—Dr. HINDE has examined the chert of beds in Lanarkshire and Peebleshire, Scotland, of the age of the Llandeilo-Caradoc series of Wales, and found it to consist, in the specimens examined, of Radiolarian shells, sponge-spicules being rare. The minute spherical bodies which make up the specimen were seen in some cases to consist of simple or concentric lattice-like shells, some with relatively long radial spines, precisely similar in character to the shells of recent and fossil Radiolaria. Dr. Hinde refers the species mostly to described genera. A number of them are figured on a plate in the Annals and Magazine of Natural History for July. The chert of the Carboniferous formation, which Dr. Hinde has extensively examined, only in one case afforded him Radiolarians. The Upper Silurian rocks of Langenstriegis, in Saxony, has afforded Dr. Rothpletz a single species of Radiolarian.

5. *Fossils in the Taconic limestone belt at the west foot of the Taconic Range in Hillsdale, N. Y.*—The town of Hillsdale is in the latitude of Great Barrington, and the limestones of the two regions are on opposite sides of the Taconic Range synclinal. Prof. WM. B. DWIGHT has recently examined a specimen of the

amorphic limestone of Hillsdale, from among my collections
he region, and finds, on slicing it, besides indistinct impres-
s of shells, a small Gasteropod, probably a *Maclurea* related
M. crenulata, though in some respects different from that
ies. It appears to indicate that the beds are Calciferous.
Millerton fossils, already described by Prof. Dwight, are in
same limestone belt, but nearly twenty miles farther south,
sdale being situated over the northern end of the belt.

J. D. D.

*Revision of the Genus Araucarioxylon of Kraus, with
piled descriptions and partial synonymy of the species;* by
H. KNOWLTON. Proc. U. S. Nat. Mus., vol. xii, 1889, pp.
-617. Also separate, No. 784, Washington, 1890.—Professor
owlton has done a useful service in clearing up this knotty
ject, which is much broader than the title indicates, since it
udes the eleven species of Cordaites founded on internal struc-
, and twenty-six species of Dadoxylon, all of which are Paleo-
, but are shown to possess the araucarian type of structure
therefore to have probably been the direct ancestors of the
teen species of Araucarioxylon from the Mesozoic and Ceno-
. The one Tertiary species of this last genus (*A. Dœringii*
wentz) is of special interest as coming from South America
re the genus Araucaria is native, thus seeming to complete
connection of a type of plants that began in the Silurian and
persists. Of *Araucarioxylon Virginianum* (p. 615) it should
said that the apparent anomaly of finding a species of that
us in the Potomac formation, characterized by the sequoian
Cupressinoxylon, has recently been cleared up by the dis-
ery that the fossil wood found at Taylorsville, Virginia, occurs
modern deposit (probably the Appomattox formation) imme-
ely overlying the Older Mesozoic or Triassic (Rhetic or Keu-
from which its materials are taken, and to which the fossil
d rightly belongs. L. F. W.

*Ueber dei Reste eines Brotfruchtbaums, Artocarpus Dick-
n. sp., aus den Cenomanen Kreideablagerungen Grönlands;*
A. G. NATHORST. Kongl. Svenska Vetenskaps-Akademiens
dlingar, Bd. xxiv, pp. 1–10, 4°, pl. i. Separate, Stockholm,
).—The large-lobed leaf figured here is believed by the author
epresent an Artocarpus of the type of the bread-fruit tree, *A
sa*, but the details of nervation are wanting. The fruits asso-
ed with it, as well as that from Oeningen which Heer called
Oeningensis, and of which Nathorst here gives a new figure,
ear without doubt to belong to the fig family, and if they are
small bread-fruits they are probably true figs. There is no
ent objection to regarding this leaf as that of Ficus. Nathorst
ws that it resembles several that have been found in American
osits and referred to Aralia, Myrica, etc., and Lesquereux in a
k not yet published, figured similar ones from the Dakota
up under the names Liriodendron, Sterculia, etc. L. F. W.

Tertiäre Pflanzen der Insel Neusibirien; von J. SCHMAL-
SEN. Mém. Acad. Imp. Sci. de St. Pétersburg, 7e serie, tome

xxxvii, No. 5, 1890, pp. 22, pl. 2, 4to.—This paper forms the second part of the series devoted to the scientific results of the expedition sent out in 1885 and 1886 by the Imperial Academy to explore Janaland and the New Siberian Islands, and contains an introduction by Baron E. von Toll, who collected the fossil plants on the Island of New Siberia which are here described by Schmalhausen. They consist largely of well known Arctic Tertiary forms, but contain several new species, including two of fossil coniferous wood. There is no indication that this flora represents an age greatly different from that of the Tertiary plant-beds of the mainland of Siberia (Tschirimyi on the Lena, Simonowa, Atschinsk, Bureja, etc.) or of the Island of Sachalin.

L. F. W.

9. *La Flora dei Tufi del Monte Somma;* by LUIGI MESCHINELLI. Rend. R. Accad. Sci. Fis. e Mat. of Naples, April, 1890, 4to. Separate, pp. 8.—Dr. Meschinelli enumerates some twenty species of leaf-prints preserved in the Geological Museum of the University of Naples that have been collected in the tufas of Monte Somma on the north flank of Mount Vesuvius. Most of them he is able to identify with living species still found in Italy. They are supposed to have been buried by the lavas prior to the historic period. L. F. W.

10. *Remarks on some Fossil Remains considered as peculiar kinds of Marine Plants;* by LEO LESQUEREUX. Proc. Nat. Mus., vol. xiii, 1890, No. 792, pp. 5–12, pl. i.—This paper was Professor Lesquereux's last contribution to paleobotany, and describes certain very peculiar organisms collected by the Rev. H. Herzer in the Upper Helderberg limestone at Sandusky and in the Portage group on Lake Erie near Cleveland, Ohio. He gave to these objects the names *Halymenites Herzeri*, *Cylindrites striatus*, and *Physophycus bilobatus*, all of which are figured. They will form new material for discussion by those who are interested in the problematical organisms of the ancient seas. L. F. W.

11. *Brief notices of some recently described minerals.*—AROMITE. In a paper upon some of the minerals of Atacama, Dr. Darapsky gives the name *aromite* to a magnesia-alum having the composition $6MgSO_4 . Al_2(SO_4)_3 . 54H_2O$. It occurs with other sulphates at Copiapo, and forms fibrous masses of a yellowish color; also obtained from the Pampa de Aroma in the northern part of Tarapaca. The name RUBRITE is also used for a mineral having the composition $Fe_2O_3 . 2SO_3 . 3H_2O$, and occurring near the Rio Loa in indistinct crystals of a deep red color.—*Jahrb. Min.*, i, 49, 1890.

TAMARUGITE.—Another article upon the Tarapaca sulphates by Dr. Schulze gives a general account of the method of occurrence and association and a detailed description of a number of species. One of these is *tamarugite;* this occurs in massive forms, colorless, and with a radiated structure; hardness $= 2$; specific gravity $= 2·03$. Its composition is expressed by the formula $Na_2SO_4 . Al_2(SO_4)_3 + 12H_2O$, differing from ordinary soda-alum in the small amount of water.— *Verh. deutsch. Ver., Santiago*, vol. ii, 1889.

QUKTENITE, GORDAITE.—In a paper upon the various ferric phates from Chili, to which attention has been directed reitedly of late, Frenzel, besides notes on other species, describes ɔ new ones. *Quetenite* occurs at the Salvador mine in Quetena, st of Calama. It is massive, of a reddish-brown color, hards $=3$, specific gravity $=2·08–2·14$. An analysis gave:

SO_3	Fe_2O_3	MgO	H_2O
37·37	22·70	5·92	34·01=100

r this the formula $MgSO_4$, $Fe_2S_2O_9+13H_2O$ is calculated. *rdaite* occurs with sideronatrite and is related to it in compoon. It is found in indistinct crystals, perhaps triclinic, and in all foliated masses with fibrous structure. It is colorless to ite or light gray, luster vitreous, hardness $=2·5$ to 3. Specific gravity $=2·61$. An analysis gave:

SO_3	Fe_2O_3	Na_2O	H_2O
50·85	19·42	22·36	7·33=99·96

e formula is $3Na_2SO_4$, $Fe_2S_2O_9+3H_2O$, which brings it near the ronatrite of Mackintosh.—*Min. Petr. Mitth.*, xi, 214–223.

LUSSATITE.—A crystalline form of silica described by Mallard forming an envelope over colorless quartz crystals in the bitun deposit at Lussat near Pont-du-Château. It has a fibrous or rous-lamellar structure, the fibers being perpendicular to the face of the crystal. They are doubly-refracting in the direcn of their length and have the opposite optical character (+) to alcedony. The specific gravity is 2·04 and the mean index of raction for D 1·446, in both points approximating to the charter of opal. Chemically, it consists of pure silica for the most rt, but in part mixed also with amorphous silica or common al. Its occurrence at a number of localities, associated with al is noted.—*C. R.*, vol. cx, 245, Feb. 3, 1890.

12. *On the supposed occurrence of Phenacite in Maine—a cortion;* by W. S. YEATES (communicated).—In the April number this Journal, I announced that I had identified phenacite from bron, Maine; and that, among other planes, I had observed basal plane, *O*. This announcement was based upon a preinary examination, the angle between the adjoining planes of yramid, 156° 46′½, being practically the same as that between and ⅔-2 of phenacite, viz: 156° 44′. The apparent infusiity of the mineral, when first examined, coupled with the strik resemblance of the crystal to phenacite in habit, served further mislead. A more careful examination, recently made by me, closed the fact that the mineral was not phenacite; and a antitative analysis, by Mr. L. G. Eakins of the U. S. Geological rvey, has proved it to be apatite. The plane, which was at t taken for ⅔-2 of phenacite, is the pyramid ½. The unusual t habit of these apatite crystals is well worthy of note.

J. S. National Museum, Aug. 7th, 1890.

13. *Tableaux des Minéraux des Roches, resumé de leurs proiétés optiques, cristallographiques et chimiques par* A. MICHEL-VY et A. LACROIX. Paris, 1889. (Baudry et Cie.)—These les form a useful supplement to the well known work of the

same authors recently published (this Journal, xxxvii, 414), giving the data therein contained in convenient tabular form. The active investigations of the authors have served to fill out and complete to a remarkable extent our knowledge of the optical constants of many important species.

14. *Index der Krystallformen der Mineralien*, von Dr. VICTOR GOLDSCHMIDT, vol. ii, pp. 335–546, Berlin, 1890 (Julius Springer). —The Nos. 6 and 7 now published, of Goldschmidt's great work, include the species from Magnesite to Pyroxene, completing the second volume. The completion of the third volume and thus of the entire work is promised before the close of 1890.

15. *Report of the Royal Commission on the mineral resources of Ontario, and measures for their development.* 566 pp. 8vo. Toronto, 1890 (Warwick & Sons).—This volume contains the report of the Commissioners appointed to enquire into and report upon the mineral resources of the Province of Ontario and upon measures for their development. The Commissioners are J. Charlton, *Chairman*, Robert Bell, Wm. Coe, Wm. H. Merrill, Archibald Blue, *Secretary*. The report gives a sketch of the geology of the Province with special reference to economic minerals, with notes on mines, locations and works visited; also a statement of the influence of commercial conditions upon mining industry, mining laws and regulations, on the smelting of ores in Ontario, etc.

III. MISCELLANEOUS SCIENTIFIC INTELLIGENCE.

1. *Report of the U. S. Coast and Geodetic Survey for* 1887. 514 pp. 8vo, with 42 maps and sections.—This Report contains among its appendices, the following reports: H. MITCHELL, on the movements of the sands at the eastern entrance of Vineyard Sound; C. A. SCHOTT, Fluctuations in the level of Lake Champlain; Lieut. J. E. PILLSBURY, Gulf Stream Currents along the Florida Straits; C. A. SCHOTT, Magnetic work of the Greeley Arctic Expedition; H. MITCHELL, on the results of the Physical Survey of New York Harbor; also a General Index to the progress sketches, illustrations, maps and charts, in the Annual Reports of the Survey from 1844 to 1885, and a Bibliography of Geodesy. The following facts are here cited:

Lake Champlain.—The greatest depth of Lake Champlain is 402 feet, "and consequently parts of the bottom of this lake descend 300 feet below the level of the Atlantic Ocean." The lake is highest in May when it is 2·18 feet above the mean, and lowest in September when it is 0·96 feet below it; it is above the mean also in the months of March, April and June.

The Gulf Stream.—On a transverse section of the Stream between Cuba and Yucatan ("section DD") where the depth of water at middle is over 1100 fathoms, the line of maximum velocity is situated about 5 miles east of the 100-fathom curve on the Yucatan Bank, and the zero velocity is at or near the bottom;

the zero to the eastward is at approximately the same depth, fathoms.

ı the transverse section between Havana (Cuba) and the Re- a Shoal, of the Florida reef, just east of the Tortugas (section the curve of zero-velocity two-thirds of the way across to ı, at station 4, has a depth of more than 750 fathoms; at ons 2 and 3 (on the Florida side of station 4), 200 and 380 ly, and at 5, on the Cuba side, only 220.

ıe report states that the approximate volume of water flowing ıgh the section DD is 110 billion tons per hour; through the on CC 103 billion tons, and the section A, which is that be- n the Fowey Rocks, Florida, and the Bahamas, 95 billion It is added, "The evaporation from the Gulf of Mexico the eddy current would account for the excess at section DD. ection CC, in the calculation, the directions have been taken owing east, and this, of course, gives too great an amount; excess would probably be accounted for by this difference the eddy, leaving the volume actually flowing east equal to found at section A."

ctions A and DD are alike in their northward flow, in the ral contour of the bottom, in the depth at which the current hes a zero velocity where it is not influenced by shoals (it g 300 to 350 fathoms in each), and in having the axis of city situated on the slope of the bank on the west side of the am. The maximum velocity in section A is 5·25 knots per , in section DD, 6·25 knots; the first was the monthly maxi- ı without the effect of inertia, the last the monthly maximum bined with the inertia of the stream. The idea of Lieut. ry that the middle of the stream is somewhat elevated re- es support, if by middle the axis is understood, from the fact current bottles thrown overboard west of the axis invariably g up on the Florida Coast, and those east of it are never d from, they going into the broad Atlantic.

he American Magnetic Pole.—The Report of Mr. Schott ıe Magnetic Work of the Greeley Expedition closes with the wing words: "In close connection with the scheme of physi- esearches undertaken by the International Arctic Committee, desirability of a new determination of the American pole of does not appear to have been urged. * * * From the of Hansteen, early in this century, to the present time, efforts been made to trace out the supposed motion of the intersec- of the so-called magnetic axis with the surface. While some icists hold it to be fixed in position, others believe it to have w secular motion of limited extent, and still others would to it a rapid motion with a path which would carry it clear d the geographical pole. The time has certainly arrived n in this matter facts should take the place of speculation. writer has the assurance of the willingness of three distin- hed American Arctic explorers to undertake this task; the thing lacking is the necessary funds to sustain the explorer, say for two years. Here surely is a fine field open in which to gain well-merited distinction."

2. *Aid to Astronomical Research.*—Miss C. W. **Bruce** has offered the sum of six thousand dollars ($6,000) during the present year in aid of astronomical research. No restriction will be made likely to limit the usefulness of this gift. In the hope of making it of the greatest benefit to science, the entire sum will be divided, and in general the amount devoted to a single object will not exceed five hundred dollars ($500). Precedence will be given to institutions and individuals whose work is already known through their publications, also to those cases which cannot otherwise be provided for or where additional sums can be procured if a part of the cost is furnished. Applications are invited from astronomers of all countries, and should be made to the undersigned before October 1, 1890, giving complete information regarding the desired objects. Applications not acted on favorably will be regarded as confidential. The unrestricted character of this gift should insure many important results to science, if judiciously expended. In that case it is hoped that others will be encouraged to follow this example, and that eventually it may lead to securing the needed means for any astronomer who could so use it as to make a real advance in astronomical science. Any suggestions regarding the best way of fulfilling the objects of this circular will be gratefully received.

Harvard College Observatory, **Edward C. Pickering.**
Cambridge, Mass., U. S. A., July 15, 1890.

3. *Construction of buildings in Earthquake countries.*—Volume xiv of the Transactions of the Seismological Society of Japan (1889) consists of a discussion by **John Milne** of the subject of suitable buildings for earthquake countries. It describes disasters and the best ways of avoiding them in constructions, and illustrates the subject with plans and views.

4. *A Handbook of Engine and Boiler Trials and the Indicator and Prony Brake.* For engineers and technical schools; by R. H. **Thurston**. 514 pp. 8vo. New York, 1890 (John Wiley & Sons).—The author has given us here a standard work of reference in a department of great practical importance in civil engineering, and has thus filled a place not occupied before. The instructions given for the application of the trials are practical and clearly stated, and the methods to be used are described with precision and conciseness, and the engineer will find this fresh and accurate handbook of great value to him.

5. *The Science of Metrology;* or Natural Weights and Measures. A challenge to the Metric System; by the Hon. E. **Noel**. 83 pp. London, 1889 (Edward Stanford).—In this little book the author has attempted to show that "by a little amending the existing English measures can be evolved into a system scientifically as well as practically superior to the Metric."

Gesammelte mathematische Abhandlungen von H. A. Schwarz. Vol. i, 338 pp., with 4 plates; vol. ii, 370 pp. Large 8vo. Berlin, 1890 (Julius Springer

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[THIRD SERIES.]

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ART. XXXV.—*A description of the "Bernardston Series" of Metamorphic Upper Devonian Rocks;* by BEN K. EMERSON.*

1. *Description of the Region.*—The terrace sands of the Connecticut river are narrow upon its western side where the river crosses the State line, and they continue with little increase of width for four miles southwesterly, and then, as they enter Bernardston, their boundary upon the older rocks turns abruptly west, and runs for seven miles a little south of west, past the village of Bernardston, and along the north line of Greenfield. Bernardston village stands just in the middle of this line, and at the mouth of a narrow valley, up which a lobe of the alluvial sands reaches northwardly for nearly two miles. On the west, this valley is bounded by the high ridge of West Mountain, made up of the contorted argillite which stretches in a narrow band far north, across Vermont, and disappears below the river

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* The introductory part of this paper, giving a history of previous investigations in the region, is here omitted. The publications mentioned in it, which are of chief interest in this connection, are: Prof. Edward Hitchcock's Report on the Geology of Massachusetts, 1833, and 2d ed. 1835, the latter mentioning the discovery of Crinoids and giving figures; the Report on the Geology of Vermont, by E. and C. H. Hitchcock, i, 447 and ii, 598, 1861; the two papers of J. D. Dana in this Journal, III, vi. 339, 1873, and xiv, 379, 1877; a paper by C. H. Hitchcock in this Journal, xiii, 313, 1877; also observations by C. H. Hitchcock in the Geology of New Hampshire, ii, 428, 1877; a short paper by R. P. Whitfield on the fossils of Bernardston, based chiefly on specimens of new forms discovered by Prof. Emerson, published in this Journal, xxv, 368, 1883.

The investigation by Prof. Dana had in view the chronological canon with regard to crystalline rocks—that kind of rock was a safe criterion of geological age—and that, under it, "staurolite crystals were as good as fossils" for the purpose. The metamorphic Taconic region of western New England, and the

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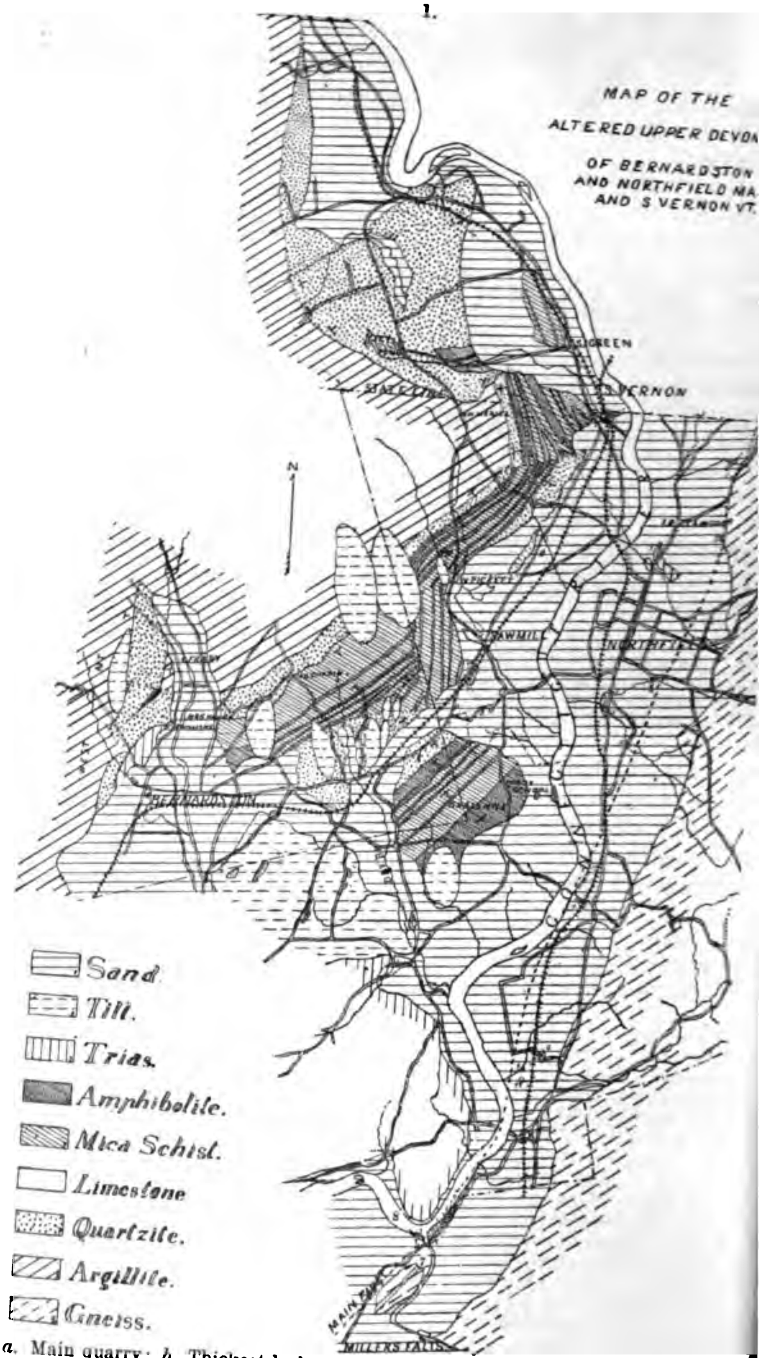

a. Main quarry; *b.* Thickest bed of magnetite; *c.* Excavation connecting limestone with quartzite; *d.* Excavation exposing fault of mica schist against limestone; *e.* Same as *d*; *f.* Contact of quartzite on argillite.

sands on the north line of Greenfield, appearing again only in the limited outcrop just west of the village of Whately, fifteen miles farther south, and in one newly discovered at the mouth of Mill River. Everywhere the slope of the West Mountain shows only the black argillite, except in a single band back of the house of Mr. Williams, a mile north of the village, where, apparently resting upon the argillite, occurs the fossiliferous series. The section has a width going up the hillside on the line of dip, of only 1050^m, and is nowhere exposed, on the strike, more than a tenth of this distance. The outcrops of the argillite to the north and south show that there can be only a very limited amount of the newer series preserved upon the hillside, while the heavy accumulation of till generally prevents one's seeing its limits or its contact upon the rock below. It approaches the argillite quite closely upon the west and in the line of strike can not be more than 3000^m long. Over against the West Mountain on the east, across the narrow valley of Fall River, rises a range of hills bounded on the south and east by the terrace sands, which is composed of a similar series of rocks in similar succession. The principal difference between the two is that on the east a dark hornblende rock, often massive, takes its place in the series while the limestone and magnetite bed of the typical section are wanting, and all the other members are somewhat more metamorphosed. Staurolite occurs in the schists, feldspar crystals and biotite in the quartzites, and hey are thrown into complex folds and greatly faulted. They lie in fact along the center of the great synclinal of the Connecticut valley which is an area of maximum disturbance of the rocks quite across the State. These discrepancies become less mportant when it is noted that hornblende exists in considerable quantity directly above the Williams farm limestone, and the second bed of the same limestone in South Vernon is encased n hornblende schist. Across the river in Northfield the white

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Bernardston of central, being known to afford fossils, the former of Lower Silurian age and the latter of Lower or Upper Helderberg, these were selected as regions for ascertaining what kinds of crystalline rocks might be of these different periods for comparison with Archæan crystalline rocks. (The Lower Silurian age of the Taconic system was hardly questioned in 1873 by any one.) Prof. Dana's papers on the Bernardston region describe among these rocks, besides the limestone and quartzyte, garnetiferous mica schist, staurolite slate, gneiss, and various hornblendic rocks, including quartz-syenite.

Prof. Emerson has given the region a thorough investigation, in which he has removed the doubts as to the relations of the beds, made out, as far as possible, the system of faults and flexures, studied the rocks as to their kinds and transitions, and determined the age of the series to be Upper Devonian. The paper will be accepted in America, and should be elsewhere, as putting the facts beyond doubt that gneiss, dioryte, granite, and the other crystalline rocks described are not always of Archæan or pre-Cambrian make; that dioryte and granite are not always of igneous origin; and these conclusions are made sure on the well-established criterion of age, that is, fossils—Crinoids, Corals, Brachiopods. J. D. D.

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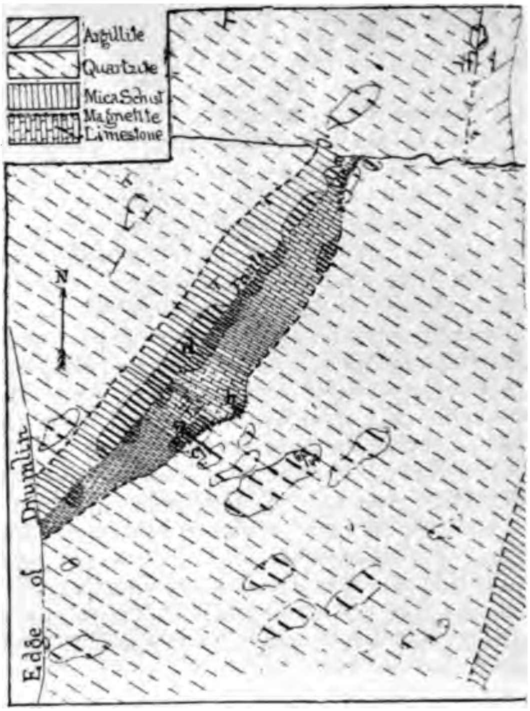

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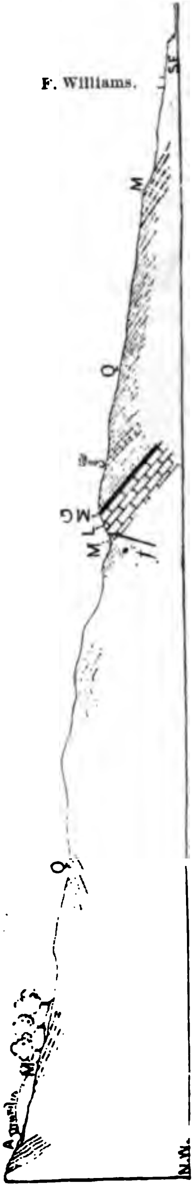

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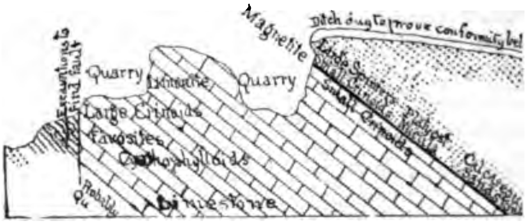

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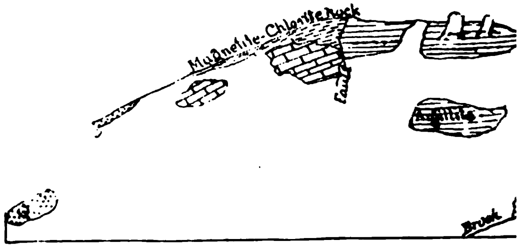

Fig. 2. Map of Devonian rocks, Williams Farm; 3. Section of same; 4. Section [illegible]y, *including a* to *c* of map, fig. 2; 5. corresponding to *e*, of fig. 2,—the brool
lt, *faulting* the quartzyte.

saccharoidal quartzite extends to the base of the Northfield Mountain and is there bounded by a north-south fault, while only a single outcrop of schist is exposed.

2. *The relation of the Bernardston series to the Argillite.*—It was originally assumed by President Hitchcock that the argillite and the schists of this series were conformable. Professor J. D. Dana,[*] finding the argillite about a half mile west of the limestone to have a much higher dip, decided that they were unconformable to, and much older than, the upper series, and this conclusion was accepted by Prof. C. H. Hitchcock.[†] I have, in tracing the distribution of the quartzite, given five localities where the boundary of the quartzite and argillite is well exposed, and I could increase the number, and in each case there is apparent conformity and a uniform passage from the common argillite, into argillite with minute garnets and minute biotite spangles, fine-grained black quartzite graduating into coarser quartzite and conglomerate. The argillite is extremely corrugated and often cleaved, and observations of dip a rod from the contact are of no value as settling a question like this.

3. *The Williams Farm Section.*—See maps 1 and 2 and sections, figs. 3, 4, 5. The long band of the rocks of the Bernardston series along the lower slope of the West Mountain has been brought into its present position by extensive dislocations and is plainly cut by two transverse faults which run approximately with the brook gorge north of the limestone and with the larger gorge of Fox brook half a mile south. The area between containing the fossiliferous limestone is the one here described.

Passing up the hillside, back of Mr. Williams's barn, the first bed and the upper one on the section (fig. 3) is a dark muscovite schist, which is exposed in a single small quarry and separated by a depression which runs with the strike, and which I have supposed in the section to be occupied by the same schists and to have been formed by their erosion. The outcrops are almost continuous across the quartzite and limestone which follow, to the second outcrop of schist, where a similar depression separates the latter from the second band of quartzite, which I have in like manner supposed to be occupied by this schist. The thicknesses given in the section are, with this explanation, the result of careful measurement; and the elevations taken with two closely agreeing aneroids, and referred to the sea level by means of the height of the railroad station at Bernardston, corrected so as to agree with Gen. Ellis's survey of the Connecticut River.

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[*] This Journal, III, vi, 343.

[†] Geol. N. H., ii, 433, 1887.

Section of the Williams' Farm Rocks.

1.	Garnetiferous mica schist	22·5 m.
2.	Micaceous quartzite and conglomerate	135· "
3.	Magnetite, maximum	1· "
4.	Limestone	6· "
	Fault	
1.	Mica schist	35· "
2.	Quartzite and conglomerate if conformable with the mica schist	200· "

The beds below the fault are a repetition of those above.

a. The Argillite (fig. 3, A, west end).—Beginning nearly a mile northwest of the Williams house, and just north of the point where the road over West Mountain bends sharply west, a long ridge of the typical elaborately contorted argillite extends northerly. Going east a drumlin conceals its contact with the newer rock, and I have represented beneath the till a comformable contact of the argillite and the quartzite as I have found it everywhere in the region. (See fig. 2.)

b. The western outcrop of the mica schist.—Where the series outcrops for the first time after crossing the drumlin, a small area of the mica schist of this series has recently come to my notice. It is a garnetiferous mica schist, like the more eastern outcrops, and it lies plainly in a small synclinal of the quartzite. It lies ten rods south of the western of a row of great chestnuts which crown the hill.

c. The western exposures of the quartzite.—The discovery of the schist just described makes plain the structure of these quartzite outcrops with their western dip. As they lie in a small synclinal the quartzite makes a corresponding anticlinal before reaching the outcrop of the mica schist. The rock is dark gray quartzite, at times conglomeratic, weathering very rough, with strike and dip very irregular and uncertain, with many slight slips and crushings, indeed, often completely brecciated and recemented with limpid quartz. Locally it passes into a black siliceous slate by the microscopical development of biotite and the accumulations of coaly matter. A few scales of the former mineral can be seen with the lens. Going up the hillside from the limestone along the line of dip, two small ledges of the rock appear, as may be seen from the section, widely separated from each other, and from the rocks above and below.

It is not difficult to find, among the less crushed portions of each ledge, pieces which agree exactly with the quartzite above the limestone, especially that which outcrops a few meters above the latter, and its peculiar appearance is largely due to crushing and infiltration of quartz. The same result is reached by examining the quartzite ledges along the strike north and south from this point and comparing them with the "upper quartzite."

d. The mica schist west of the limestone.—This rock is a dark, even-bedded, muscovite schist, so fine grained as to be almost indistinguishable from the even-bedded varieties of the argillite below, with its glistening surface pitted here and there by minute hollows from which small red dodecahedral garnets have fallen out. It is abundantly marked by small bodies, which appear much like minute altered chiastolites just visible to the eye. The minute chiastolite-like forms prove to be made up externally of bands of quite large muscovite plates, each normal to the long sides of very impure biotite crystals, the latter placed transversely to the bedding of the rock. Under the microscope the rock shows a fine, scaly, colorless ground mass, dotted abundantly with coaly matter, and made up mostly of muscovite plates with some apolar matter, apparently opal. The constituents are a little larger than in the argillite, and the coaly matter less abundant. No kaolin could be detected. The much-fissured clear garnets are surrounded by a black band from the repulsion of the coaly matter, within which a broad decomposition band of chlorite in twisted scales appears which often extends nearly to the center. They contain large grains of quartz irregularly arranged. The biotite incloses garnet, and the muscovite forms caps around the garnet, and arranges itself symmetrically to the biotite, so the order of crystallization is very generally garnet, biotite, muscovite. The large amount of impurity in the biotite indicates that when it formed the rock was more carbonaceous than at present. Leucoxene occurs in yellowish white grains less abundantly than in the argillite

e. Fault between the schist and limestone, *d*, fig. 2.—The bed last described dips under the limestone apparently, with the strike N. 70° E. and dip 25° to 35° E. But just opposite and northwest of the largest excavation in the limestone, and under a small apple tree where the schist seemed certainly to go under the limestone, and where Prof. Dana and the writer dug away and followed it for six inches under the limestone, later I had excavations made, having doubted the reality of the apparent conformable superposition, because the bed of limestone rested on the schist with abrupt transition and total want of continuity. I found the two rocks to be faulted against each other, the wall of the limestone bending under for a few inches and then going down vertically, and the schists, so flat in the exposures below, were here crumpled up sharply and ground into shapeless masses against the limestone. I followed the fault down more than a meter without finding the bottom of the limestone, but found mingled in the crunched schist fragments of the chloritic rock, which lies below the limestone and is exposed in the bluff to the north. At a later date I had further excavation made, uncovering the northern bluff where also the mica schist approached the limestone at its northern end, and I exposed here a zigzag fault line between the schist on the west and the black, magnetite-pyrite-chlorite-limestone, and below this with the white limestone itself, *e* on map, fig. 2. The fault plane is nearly vertical. The relation of the beds at this point are made plain by fig. 5. This latter excavation was made by direction of the United States Geological Survey.

f. The Limestone.—The limestone which forms the center of interest of the section, is exposed in many old pits, extending from the bluff overlooking the brook, to the largest opening overhung by birches, where the rock is most fossiliferous; and the line of outcrops is continued, by more scattered openings, farther southwest. It extends in all about 125 m. from northeast to southwest, that is along the line of strike. It is for the most part a coarsely crystalline, saccharoidal limestone, at times so coarse that cleavage pieces of calcite 8 centimeters across can be obtained from it. Below it is in thick beds with stratification mostly obliterated, while the upper portion, for about 2 meters, is thin-bedded, finer grained and micaceous. The rock contains some pyrite, which with the more abundant deposit of the same in the bottom of the quartzite, has been the source of the great amount of porous limonite, which fills broad veins and great cavernous spaces in the limestone. Its modern formation is attested by the rootlets changed into limonite enclosed in it.

It makes a strange impression to turn over a mass of coarsely crystalline limestone, and find the weathered surface covered with Crinoid stems or Corals. In masses showing no trace of fossils, these are brought out equally well in thin sections; and I have even observed a fragment of the shell of a Terebratula, preserving the punctate structure, the pores agreeing closely in position and measurement with those of modern genera.

In the section fig. 4 all the fossils known are assigned to their proper horizon so far as known to me. I would especially note the fact, to which my attention was first called by Professor J. M. Clarke, that the line of division between the two paleontological horizons represented falls well down in the limestone, and that the upper meter of the latter is thin bedded and wants the forms found below, while it carries the peculiar annulate crinoid stems found also very abundantly in the quartzite above.

The shaly limestone is in places much fissured and cemented at times with veins 5–10^{mm} wide of a completely granitoid mixture of quartz and muscovite, the plates of the latter extending quite across the vein, while the cemented rock still shows abundant crinoid stems. The limestone contains:

$CaCO_3$ 98·38 Fe_2O_3 0·62 SiO_2 1·00

g. The Magnetite bed.—In the largest opening under the main group of birches the limestone for the upper three inches is impregnated with magnetite and the quartzite above this is fossiliferous. Following this boundary north 15 meters the ferruginous horizon swells out to a thickness of one meter and is here represented by a bed of porous limonite. At the same distance farther north it is a bed of fine-grained magnetite, often pyritous, and in one place garnetiferous, and nearly a meter thick. It is of limited extent, but furnishes blocks of ore not to be distinguished from Laurentian magnetites. Analysis indicates phosphorus as well as sulphur.

A little farther north where the base of the quartzite is exposed over the thickest magnetite, it is a dark gray quartz schist, abounding in pyrite, much crushed, and the fissures covered with small fresh rosettes of gypsum crystals, and with drusy crusts of a mineral of earlier formation, now much decomposed, which seems to be prehnite; but from the small size (5^{mm}) of the crystals, and their altered state, they could not be certainly determined. The form of the crystals is peculiar, as if each were made up of half a dozen long square prisms bounded above by a dome and placed side by side, producing a form like a section of a thick saw blade.

At the point where the magnetite is thickest—one meter—I exposed by digging, its contact with the limestone below and with the quartzite above, and found it to pass gradually into the white limestone below and to graduate above into a thick layer (20^{mm}) of a compact grayish black rock, rusting red and glistening under the lens with fine biotite. Under the microscope it proved to be a granular limestone with regularly disseminated biotite scales, of so strong absorption that basal sections are opaque except in the thinnest portions, and then greenish brown. It is thus unlike all the micas of the region and perhaps is phlogopite. The mica is abundantly and regularly spread through the mass, exactly as in a whetstone schist. A single crystal of hornblende, little coaly matter and rust, the fragment of a punctate Brachiopod and the arm-piece of a Crinoid occur in the slide. This rock graduates into the black pyritous quartzite above; all the beds are so entirely continuous, and undisturbed, that it is impossible to think of faulting, or any irregularity at the junction, any more than at the opening farther south under the birches, where the junction is equally undisturbed. The paleontological evidence reinforces the stratigraphical for the continuity of the limestone and the quartzite. At its northern end, overhanging the brook in the most northerly digging, the magnetite layer is a black, magnetite-pyrite-chlorite rock. Fig. 4, and *e*, fig 2. This rock which caps the limestone contains amphibole, biotite, chlorite and little pyrite, magnetite and hematite, and an amorphous mineral resembling serpentine. The biotite is very dark colored in basal sections and in places changing into chlorite and passing at the edges into the serpentine-like mineral. In the larger part of the section it has a fibrous structure the fibers grouped into large elongate patches, at times radiate and the whole resembling a fine hornblende schist. It is of oil-green color, shows only in patches a trace of dichroism, and with polarized light there is a faint predominance of extinction at about 3° from the long axis of the fibrous groups, which proceeds from the whole group; and this is overlaid as it were by the aggregate polarization of the serpentine-like mineral in fine scales and needles. An analysis made for me by Mr. G. H. Corey, of the class of '88 in Amherst College, gave:

$$SiO_2\ 42{\cdot}56,\ Fe_2O_3\ 44{\cdot}25,\ CaO\ 13{\cdot}11 = 99{\cdot}92.$$

The absence of magnesia from this analysis is puzzling, as the product of decomposition of the hornblende resembles serpentine strongly. It is possible that a highly ferruginous amphibole has developed in the magnetite-calcite bed and this has changed into a ferruginous mineral allied to chloropal.

h. The eastern bed of Quartzite.—Under the birches, as represented in the section, fig. 4, one meter of a thin, evenly laminated, light gray quartz-schist caps the limestone, and is very rusty especially at the base, and porous from the amount of pyrite and calcite that has been removed. Two-thirds the way up a layer of about 10^{cm} thickness is crowded with flattened and distorted casts of Brachiopoda and of annulate Crinoid stems; a large Spirifer, with septa like *S. disjuncta*, is very abundant. Traces also of *Rhynchonella* and *Orthis* are common, of *Nucula* and *Platyostoma* rare, and the ringed Crinoid stems again very common. The material I have been able to obtain has been submitted to Mr. J. P. Whitfield and discussed by him in this Journal.* The fossiliferous bed is of very limited lateral extent, and I could trace it only about three meters.

The next outcrops, 15 m. east, and about 2 m. above the bed just described, is a hard gray quartzose conglomerate, with white flattened quartz pebbles, 10–25^{mm} across. Under the microscope, the rock is seen to be made up of angular grains, with large cavities filled with water, containing spherical ighly refringent globules with moving bubbles. It carries lso carbonaceous matter in globules, magnetite, pyrite, a little ornblende and muscovite, which latter forms the partings etween the pebbles. It resembles much more closely the uartzite described above, p. 268, *c*, than it does the rest of the uartzite above and below it. The quartzite continues very ompact, vitreous and unevenly bedded for 20 m. down the ill, and in its upper portion carries garnets. It then becomes hin-laminated, separating into layers about 30^{mm} thick, which re, in fresh cross section, white to bluish vitreous quartz, and he surface of the plates is coated with muscovite. It is finely ointed, and the surfaces of the broad plates are somewhat varped, giving varying dips. Higher up it is cut by great 'eins of quartz, and in the last outcrop before reaching the ipper schist it is again a compact quartzose conglomerate. The strike of the rock averages N. 60° E., but varies between N. 25° E. and N. 70° E. The dip is generally 30°–35° E. but 'aries from 25° to 50°. At the large quarry a single surface hree meters square gave 25° above and 42° below.

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* Vol. xxv, page 368, 1883.

i. On the conformity of the Limestone and the overlying Quartzite.—Since the limestone, the magnetite band and the 'erruginous quartzites immediately overlying the latter are visibly conformable, and all contain the same fossils as several imes indicated above, there remained in this direction only one question unanswered, namely, what was the relation of the eries exposed in the large quarry at the birches and mentioned n the last paragraph, to the quartz conglomerate with flattened ebbles exposed 15 meters to the east and thus to the whole nass of the quartzite. The latter seems much more metamorhosed and it might be urged that a fault intervened between he two. On the other hand the conglomerate is typical of hat extending from this point northeast to South Vernon and hence north nearly to Brattleboro, and the exact proof of their onformity would greatly enlarge the value of the limestone or fixing the age of the rocks. For this reason I had pits ug three meters apart from the top of the rusty quartzite to he nearest outcrop of the conglomerate to the east, and found he quartzite apparently continuous and no indication of any ult between the two.

As this did not wholly settle the question I had a trench ug exposing the ledge the whole distance from the fossilifrous quartzite to the conglomerate. It exposed a continuous urface of the black shaly quartzite for forty-seven meters and onglomerate for three meters, with strike N. 50° E., dip 40° E., nd each layer dipped conformably beneath the succeeding one nd the possibility of any fault was wholly excluded. See secion 1. Fig. 3 and *c*, fig. 2.

j. The upper outcrop of the Mica schist.—This outcrop occurs 50 meters distant from the uppermost outcrop of the quartzite, in a single small ridge 40 meters long and 20 meters wide, with strike N. 48° E. (41° to 51°) and dip 30° E. (25° to 34°). Figure 3, east end.

It is a dark gray fissile muscovite schist, splitting into thin slabs. Its surfaces are pimpled with small garnets and biotite crystals, or pitted by the cavities left when the crystals remained in the adjoining slab of schist; and it carries abundantly small dark brown biotite crystals, long prisms with rounded angles $1{\cdot}5 \times 2{\cdot}5^{mm}$, and placed generally with their broad cleavage face at a large angle to the bedding plane of the rock, and so visible only as dull black lines on the latter plane, and as shining black scales when the slab is broken across. In tracing the same rock across the valley, still another curious uniformity of position was observed. The great majority of the scales lie with their flat surface, the face *O*, normal to the line of strike, and the longer diagonal, here greatly elongated, parallel with the dip, a phenomenon entirely comparable with the "stretching" of gneiss, and indicating a pressure and an incipient structure at right angles to the present one.

Microscopically the rock shows exactly the same scaly coal-dusted mass, consisting largely of muscovite plates irregularly bounded, as does the schist adjoining the limestone, *d*, p. 269, only on a slightly larger scale. The biotite crystals are also bordered in the same way by a layer of larger and purer muscovite scales, but not so constantly, nor is the layer so broad and regular.

The mica crystals are true biotite (meroxene, $\rho < v$), as proved by study of cleavage scales. Some slides show in abundance grains of opaque black ore with some grains partly changed to an opaque white; others, in place thereof, are grains of exactly similar size and arrangement of an opaque yellowish white material; I judge therefore the former to be menaccanite, the latter leucoxene. Limpid dodecahedral garnets, magnetite and pyrite also occur. The only microscopical distinction between the upper and lower schists is in the somewhat larger size of the constituents, and a slightly greater clearness of crystalline texture in the upper, so that one can affirm more certainly the absence of any clayey matter. Macroscopically the upper schist is somewhat thicker bedded, of more uneven surface. A lens is hardly needed to see the muscovite scales on the surface of the slabs, and the biotite and garnet are conspicuous and abundant accessions, instead of being only minute and, in the case of garnet, also rare.

4. *The synclinal north of the brook in the Williams pasture.* North part of map, fig. 2.—Within the area just described the

ocks dip mostly to the east, while north of the brook the struc-ure is decidedly different. A section east and west through he woods shows a great synclinal of the quartzite in the argillite.

Following down the brook from the limestone to where the oods end and then skirting the latter for a few rods north where the first wood road enters them, a little way in and t the first outcrop on the south side of the road, there is a ell exposed contact of the argillite beneath and the quartzite bove; strike N. 20° E., dip 20° W.; the argillite flat fissile, ith few chloritized garnets; the quartzite a dark gray indu-ated sandstone becoming coarser higher up. The two beds eem to be plainly conformable. The argillite can be followed orth to a point in the bluff opposite C. Frary's house with niform westerly dip beneath the quartzite, and on the west of he latter the argillite is found dipping easterly beneath it, hough the junction is covered. I imagine this synclinal is cut ff on the north by a fault along the bed of Fall river, but the ocks are covered here. Directly opposite the limestone across he brook the quartzite contains dodecahedral garnets 10 to 1$^{\text{mm}}$ across, bordered by chlorite.

5. *The outcrop along Fox Brook to the south of the Williams section.*—Behind the first house on the road over West Mountain, after leaving the village, there is seen from he road a bare bluff of blue till, and below this an outcrop in he brook of Triassic sandstone; twenty rods above, the quartz-te rests conformably upon the argillite, which contains a few arnets just below the junction. It strikes N. 60° E. and dips 0° E., and the boundary is thus pushed east by the whole idth of the Williams section, though the fault which separates hem can not be exactly located.

[To be continued.]

RT. XXXVI.—*On the Circular Polarization of certain Tartrate Solutions*—III; by J. H. LONG.

IN the number of this Journal for October, 1889, I described ertain peculiarities of solutions of potassium antimony tartrate hen mixed with carbonates, borates, phosphates or acetates n amounts insufficient to produce immediate precipitation. he specific rotation of this tartrate is very high, being, (for $= 5$) $[a]_D = 141°·273$. No other metallic tartrate approaches his rotation. It was shown in the paper referred to that the ddition of sodium carbonate in small amount decreased the pecific rotation to 55°·795, and this without precipitation of the antimony. Other salts produced a marked decrease, but less than that by the carbonate.

As a problem of chemical dynamics this phenomenon possesses considerable interest as bearing on the general question of the nature of solutions, and I concluded to make it the special subject of an investigation, the chief points of which are given below.

Experiments with sodium carbonate.

For each test five grms. of the tartrate were dissolved in about 70 c.c. of water by aid of heat and then cooled to 20° C. or below. Definite amounts of the carbonate, pure and dry, were dissolved in water and added to the tartrate, the mixture being then diluted to exactly 100 c.c. at 20° C. By careful work it is possible to prepare clear solutions containing, with the five grms. of the tartrate, a gram, or more, of the anhydrous carbonate. With much greater amounts precipitation usually takes place before the polarization can be observed.

In the table below the solutions numbered 1 to 5 inclusive remained perfectly clear during several hours and were polarized in two to four hours after preparation. Numbers 6, 7 and 8 became slightly turbid and finally deposited a precipitate. The rotations were observed after twenty-four and forty hours. In nearly all cases some differences were observed in the tests made twenty-four hours apart. Such differences became very plain when the first test was made as soon as possible after the preparation of the solution. In order to show this I made cold solutions of the tartrate and carbonate, brought them to 20°, mixed and diluted quickly with the small amount of water necessary to make 100 c.c. After gentle shaking, the mixture was poured into a 400^{mm} tube, kept at 20° by water, and polarized within five minutes. The results found were very singular and interesting. They are given under numbers 9, 10 and 11. The three solutions remained perfectly clear during several hours. At the end of twelve hours number 9 had deposited nothing, but after twenty-four hours an unweighable trace separated out. Number 10 deposited nothing until after twenty-four hours. Number 11 was clear during two hours but in twelve hours a precipitate settled out, leaving the supernatant liquid perfectly clear. In all the above cases the precipitate appeared very much less than called for by the equation:

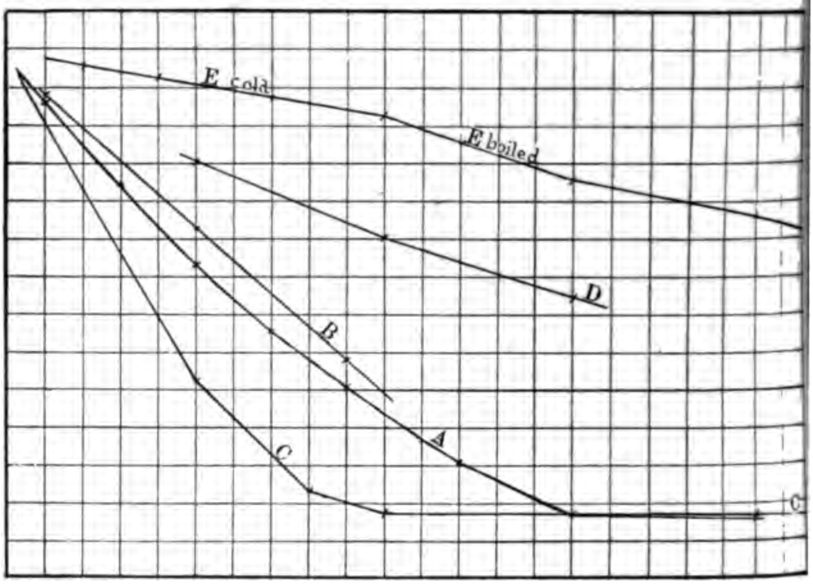
$$2KSbOC_4H_4O_6.H_2O+Na_2CO_3=2KNaC_4H_4O_6+Sb_2O_3.H_2O+CO_2$$

Analysis of the precipitate showed it to have the composition given when dried at 100°. For the five grms. of the tartrate taken, 0·7982 grm. of the carbonate should be required for complete precipitation. Analysis of the supernatant liquid showed in all cases much of the antimony in solution.

It was noticed that a slight elevation of temperature produced a copious precipitation with escape of CO_2, in cases, and to test fully the action of heat, solutions were made and mixed hot. The mixture was kept one hour on the water bath and then filtered, the cool filtrate being made up finally to 100 c.c. at 20°. The results found in these tests are given below opposite numbers 12 to 18 inclusive.

No.	Na_2CO_3	α_D	KSbOT in 100 c.c.	α_D for KSbOT + KNaT.	α_D for complete precipitation by Na_2CO_3.	
1	·1 grm.	25°·170	4·496grm.	27°·941	25°·132	
2	·3	20·690	4·226	24·417	----	
3	·5	16·628	3·482	20·764	12·853	
4	·7	13·535	2·838	17·624	----	
5	·9	10·250	2·023	13·607	3·767	
6	1·2	6·136	1·458	10·870	3·767	
7	1·5	3·510	·689	7·094	3·767	
8	2·0	3·301	·219	4·824	3·767	
9	·1	25·582	5·000	28·207	25·132	5 minutes.
9	·1	25·580	5·000	28·207	25·132	30 “
9	·1	24·480	5·000	28·207	25·132	12 hours.
10	·5	18·620	5·000	28·207	12·853	5 minutes.
10	·5	17·930	5·000	28·207	12·853	30 “
10	·5	16·670	4·716	26·814	12·853	40 hours.
11	·9	11·570	5·000	28·207	3·767	5 minutes.
11	·9	11·500	5·000	28·207	3·767	10 “
11	·9	11·132	5·000	28·207	3·767	25 “
11	·9	10·550	5·000	28·207	3·767	65 “
11	·9	10·339	3·569	21·188	3·767	12 hours.
12	·1	24·185	4·442	25·473	25·132	
13	·5	10·500	2·360	15·245	12·853	
14	·8	4·580	1·057	8·908	3·767	
15	1·0	3·568	·634	6·828	3·767	
16	1·5	3·495	·317	5·297	3·767	
17	2·0	3·495	----	----	3·767	
18	5·0	3·380	----	----	3·767	

From the table, and more readily from the curve marked A, in which the ordinates represent rotations and the abscissas amount dissolved, it will be seen that with the increase in the amount of carbonate added there is a decrease in the rotation. At first the decrease is nearly directly proportional to the amount of carbonate, but later, after the addition of enough to produce precipitation, the change in the rotation is less rapid. If we consider the first tests made with solutions 9, 10 and 11 it will be seen, as shown by curve B, that the decrease in the angle of rotation varies regularly with the amount of added carbonate, the reaction not being at all obscured by precipitation. A molecular re-arrangement of some sort, undoubtedly an interchange of bases, must take place here. In the solutions prepared at the boiling temperature the decrease in the rotation is rapid until we pass the one containing ·8 grm. of the carbonate, which is theoretically sufficient for complete precipitation. In the solutions with larger amounts of the carbonate the change in the rotation is slow, as shown in the curve C. In the fourth column of the table above I give the amounts of potassium antimony tartrate left in solution, as determined by precipitation of the antimony as sulphide, and



calculated on the assumption that it is held as tartrate and not as antimonite or other compound. In column five are given the rotations calculated for these amounts of the antimony potassium tartrate plus that of the sodium potassium tartrate formed corresponding to the decrease in the other. In column six are given results calculated on the assumption that the added sodium carbonate precipitates antimony in the proportion given in the equation above. On this assumption for solutions containing more than ·7982 grm. of the carbonate the rotation should be that of the Rochelle salt equivalent to 5 grms. of the antimony compound taken. In the values given I have not taken into consideration the slight decrease in the tation of Rochelle salt in presence of excess of sodium car- nate.

But the calculated rotations approach those of actual obser- ition only in the cases of the solutions with 0·1 grm. of rbonate, and in those with very large amounts of the latter, served after long standing or boiling. No simple relations n therefore be traced in this way, and it is evident that a rt of the antimony must be held in solution in some other y than as tartrate.

In mixing the solutions at a low temperature no precipitate as formed and no CO_2 given off. It is well known that the dition of acids to tartrate solutions decreases their rotation, ainly perhaps, from formation of bitartrate, and the idea ggested itself that this may be the action of the carbonic acid the present mixture. An experiment tried with Rochelle lt after saturation with the gas failed to show, however, a wered rotation. Slightly lower results were found by mixing e Rochelle salt with sodium bicarbonate.

That an important reaction takes place in solution can, how- er, be shown in another way. I prepared several solutions f the potassium antimony tartrate containing exactly 5 grm. something less than 100 c.c. of cold water. To one of them little litmus was added, after which a solution of sodium rbonate of exactly 2 per cent strength was run in from a urette. An alkaline reaction did not appear immediately, but e final change of color was not sharp enough for an accurate etermination. Another solution was tried with phenol- hthalein, and here good results were found. In several trials etween 74 and 78 c.c. of the carbonate solution were required r coloration. If the assumed equation of decomposition is rrect, for 5 grms. of the tartrate we need practically 0·8 gram f the carbonate. This amount is contained in 40 c. c. of the lution used and it required nearly double that volume for oloration, which reaction suggests the formation of a bicar- onate if we bear in mind that such salts are neutral to henol-phthalein. If it is also taken into consideration that in ur titration a little gas is readily lost by agitation, it will be en that practically the proper amount of alkali is added to omplete the reaction above. From these tests it is apparent hat a reaction between the tartrate and carbonate begins mmediately on the addition of the latter, and also that the berated CO_2 is held as bicarbonate or in other form with etal and neutral to the indicator. The following equation ay express what takes place :

$$2KSbOC_4H_4O_6 + 2Na_2CO_3 + 2H_2O = 2KNaC_4H_4O_6 + Sb_2O_3 . H_2O + 2HNaCO_3; \text{ or } = 2KNaC_4H_4O_6 + 2SbONaCO_3 + 2H_2O.$$

If we calculate the theoretical rotation from this equation much closer results will be obtained than are given in column six of the above table, where only half as much carbonate was supposed to take part in the reaction. These equations would suggest an explanation of the behavior of solutions 9, 10 and 11, on standing. We may suppose at first a condition of equilibrium reached in which $HNaCO_3$ or $SbONaCO_3$ exists in solution. This equilibrium is destroyed by standing or by slight change of temperature so as to liberate CO_2 and permit the Na_2CO_3 formed to react on a fresh portion of the tartrate, giving further reduction in the rotation. When the rotation finally becomes constant quite different amounts of antimony may be left in solutions of the same original strength, as shown in the fourth column of the table, opposite numbers 5 and 11. The amount of antimony finally precipitated and the rapidity with which it precipitates seem to depend to some extent on the mechanical agitation which the solution receives.

Further light is thrown on the question of decomposition by the experiments next to be explained.

Experiments with sodium acetate and phosphate.

As I have before shown, acetates decompose the potassium antimony tartrate solution slowly in the cold but rapidly when heated. A solution containing 5 grms. of crystallized sodium acetate with 5 grms. of the tartrate in 100 c.c. gave, at 20°, $a = 25^\circ{\cdot}745$, while one with 10 grms. of the acetate gave $a = 24^\circ{\cdot}676$ instead of $28^\circ{\cdot}207$. Later tests made with solutions mixed at the boiling temperature gave these results for the filtered solutions, represented by the curve D, where the abscissas have ten times the value they have in the others:

In 100 c.c. Tartrate.	 Acetate.	a_D
5 grms.	5 grms.	$22^\circ{\cdot}125$
5	10	$18^\circ{\cdot}140$
5	15	$14^\circ{\cdot}892$

These solutions were found to be strongly acid and by subjecting them to distillation I obtained a small amount of acetic acid. The precipitates were analyzed and were found to have the same composition as produced by the carbonate, viz: $Sb_2O_3 . H_2O$. The reaction taking place is probably this:

$$2KSbOC_4H_4O_6 . H_2O + 2NaC_2H_3O_2 = 2KNaC_4H_4O_6 + Sb_2O_3 . H_2O + 2HC_2H_3O_2.$$

As a further test I prepared a solution with 10 grm. of the acetate and 5 of the tartrate and heated it for one hour on the water bath. It was then filtered. The filtrate, after addition phenol-phthalein, was titrated with half normal KOH, of ich exactly 30 c.c. was required to give color. This is the ame needed to neutralize the acid or precipitate the anti- ay of the last equation. The solution remained quite clear il about 12 c.c. of the alkali had been added, when it be- ie opalescent and finally turbid before the color reaction ap- red. In an experiment with 5 grms. of the tartrate in cold ition without the acetate exactly the same amount of alkali required for coloration, but an opalescence appeared im- liately, and no actual precipitation occurred until all the ili had been added. This experiment amounts, of course, titration of the tartrate:

$$2KSbOC_4H_4O_6 + 2KOH = K_2C_4H_4O_6 + Sb_2O_3 . H_2O.$$

ally, the experiment was varied in this way. 5 grms. of the rate and 10 of the acetate were dissolved and mixed at a temperature. Phenol-phthalein was added and then alkali oloration. Now, as before, 30 c.c. was required to give color, the reaction took place in a different manner, as a precipi- formed immediately and grew heavy as more alkali was ed. This behavior seems to indicate that the antimony is l in a peculiar manner, partly at least, in the solution con- ing the acetate. Possibly a preliminary reaction is this:

$$KSbOC_4H_4O_6 + NaC_2H_3O_2 = KNaC_4H_4O_6 + SbOC_2H_3O_2,$$

last being stable in cold dilute solution but decomposed by t or alkalies,

$$2SbOC_2H_3O_2 + 2KOH = 2KC_2H_3O_2 + Sb_2O_3 . H_2O.$$

f the above equations express the truth we can readily unt for the polarization phenomena. In fresh solutions pared in the cold the rotation is decreased because of the raction of a part of the antimony to form acetate. In the ed solutions, or in those prepared cold, after long standing, rotation may be still further reduced by the action of free ic acid on the tartrate. Some results obtained with solu- s of sodium phosphate are given below:

In 100 c.c. rtrate.	Phosphate.		α_D 3 hrs.	α_D 72 hrs.
5 grms.	0·2 grm.	cold.	27°·350	27°·345 no ppt.
5	0·4		26°·700	26°·727
5	0·7		25°·732	25°·690
5	1·0		24°·755	24°·850
5	1·5	boiled	21°·303	
5	2·0		19°·448	
5	5·0		11°·502	

These results are illustrated by the curve E. The solutions, after boiling, were strongly acid. Several tests were made with borax solutions in the same manner. They gave tests for free boric acid while the precipitate formed had the composition observed in the other cases.

From a consideration of the behavior of the several mixtures, I think it is plain that the explanation of the decrease in the rotation must be the same for all cases. This explanation is one which at first sight would scarcely be expected because of the practical silence of the literature on the subject of carbonates, acetates and phosphates of antimony. The last two have been described as stable in some of the older works. If we may assume that in these combinations the metal is held as SbO' the polarization phenomena can be readily accounted for. By mixing solutions of alkali phosphates, acetates, carbonates and borates with the tartrate in the cold there is probably first formed a temporarily stable antimony salt with corresponding amount of alkali tartrate. The observed rotation is due to this plus that of the unchanged potassium antimony tartrate. After decomposition by heat a small amount of free tartaric acid or bitartrate, with low rotation, must exist in the cases where acetic and phosphoric acids had been liberated in the reaction. In the solutions with large excess of carbonate the total antimony found probably exists in combination with sodium, the decomposing action of the carbonate being much greater than that of the phosphate, acetate or borate.

Experiments with potassium ammonium tartrate.

I have already shown that the rotation of solutions of potassium sodium tartrate is in general increased by addition of salts of potassium or ammonium and decreased by those of sodium and lithium. I have since carried out a similar investigation, using potassium ammonium tartrate as the active substance. This salt was freshly prepared from pure $KHC_4H_4O_6$ and NH_4OH and crystallized. In the following table I give a few of the results obtained which illustrate all.

20 grms. of $KNH_4C_4H_4O_6$ in 100c.c. gave at 20° $a = 24°\cdot680$, or $[a] = 30°\cdot850$, which is somewhat lower than the value given by Landolt. In presence of inactive salts the rotation is altered as here shown.

In 100 c.c. with 20 grms. tartrate.		a_D	$[a]_D$	Deviation in $[a]$.
5 grms.	NH_4Cl	24°·525	30°·656	−0·194
10	NH_4Cl	24°·480	30°·600	−0·250
5	KCl	24°·710	30°·888	+0·038
10	KCl	25°·136	31°·420	+0·570
5	NaCl	23°·790	29°·963	−0·887
10	NaCl	22°·806	28°·508	−2·342

The molecular rotation of the several tartrates which come into consideration here are, (from Landolt's results and my own):

$K_2C_4H_4O_6 = 64^\circ{\cdot}42$ $KNaC_4H_4O_6 = 62^\circ{\cdot}34$
$(NH_4)_2C_4H_4O_6 = 63^\circ{\cdot}04$ $KNH_4C_4H_4O_6 = 63^\circ{\cdot}24$
$Na_2C_4H_4O_6 = 59^\circ{\cdot}85$ $NaNH_4C_4H_4O_6 = 61^\circ{\cdot}71$

On the general hypothesis of replacement in the tartrate molecule by excess of inactive salts these numbers show why the addition of NH_4Cl should produce but a slight change, while that of NaCl must produce a much greater one in the rotation of $NH_4KC_4H_4O_6$.

These results, like those obtained with the antimony compound, suggest the value of the polariscope method in the study of problems of chemical affinity. This method has been applied in a limited number of cases but the experiments above detailed indicate a direction in which it may be developed. That a certain interval of time is necessary to complete these reactions, even where no precipitates are formed, is shown by experiments 9, 10 and 11. The polariscope affords us a ready method, possibly the only method, of following these changes, which are of sufficient importance to merit further study.

Chicago, July 10th, 1890.

ART. XXXVII.—*A Rapid method for the Detection of Iodine, Bromine, and Chlorine in presence of one another;* by F. A. GOOCH and F. T. BROOKS.

[Contributions from the Kent Chemical Laboratory of Yale College—V.]

THE conditions under which iodine may be set free and separated quantitatively from hydrochloric and hydrobromic acid by the action of nitrous acid upon the acidulated solutions of the haloid salts have been recently studied in this laboratory.* We have endeavored in the work which is here described to so modify the quantitative process that the same principles of action may be applied rapidly and easily to the qualitative detection of iodine, bromine, and chlorine, without decreasing to too great a degree the delicacy of the indications. It was found in the work referred to that when sulphuric acid is added to the aqueous solution of a soluble chloride, bromide, and iodide, with care to keep the proportion of acid within certain limits and the dilution of the liquid sufficient, no very appreciable volatilization of bromine or chlorine takes place during the complete expulsion of the iodine by boiling. For the quantitative separation of the iodine of 0·5 grm. of potassium iodide from a solution containing 0·5 grm. of potassium bromide and 0·5 grm. of potassium chloride it was found best to use from 1 to 2 cm^3 of strong sulphuric acid, and to introduce into the solution, measuring approximately 700 cm^3 in volume, 0·5 grm. of potassium nitrite, or its equivalent in nitrous fumes. It is obvious that work upon this scale is undesirable in rapid qualitative testing. For such purposes it is not a matter of moment that a portion of the substances looked for escapes the reaction, provided enough is left to furnish the indication sought. We planned, therefore, to attempt the separation of iodine from bromine and chlorine by applying the reaction just mentioned to small amounts of liquid in test-tubes, in the hope that the known losses of chlorine and bromine under the conditions would be proportioned to the strength of the solution, or in other words, that when the amounts of bromine and chlorine were very small they would escape volatilization, or that when large a sufficiency would remain to give strong tests.

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* This Journal, xxxix, 293, and xl, 145.

The detection of the iodine is, of course, simple. We chose for this purpose the reaction with sulphuric acid and potassium nitrite. If the amount of iodine present is large it shows at once in this test, and the same portion may be treated further to separate the iodine. If the amount of iodine is small it may be found, as usual, by shaking the liquid with chloroform, or carbon disulphide or other appropriate solvent for iodine; or, in this case also, the portion under test may be utilized, if it is desirable, for the separation of the iodine, and for the detection of this element recourse may be had to the exposure of red litmus paper to the fumes of the boiling solution according to methods prescribed in the work referred to above upon the quantitative separation of the iodine,—the paper taking on a gray blue color when exposed to very minute traces of the vapor of iodine, and a proportionately deeper color as the amount of iodine increases. After the iodine is separated, bromine and chlorine are easily found if present. We selected as the most available method for detecting bromine the action of sodium hypochlorite upon the acid solution and shaking with the proper solvent. For the detection of chlorine we make use of a modification of the well known chlorochromic anhydride test.

As a preliminary step to the investigation of the reliability of our method of separating iodine from bromine, tests were made, for the purpose of securing definite points of comparison, upon the degree of delicacy of the hypochlorous acid test for bromine. In these tests measured amounts of a solution of potassium bromide were drawn from a burette into test-tubes.

ortion were added a few drops of sulphuric acid, the
s diluted with distilled water to the level of a mark
tube indicating a volume of 10 cm^3, 0·5 cm^3 of
m, or of white carbon disulphide were introduced, and
was shaken after the addition of a drop of a dilute
f sodium hypochlorite. The results of these tests are
:—

	Total Volume.	Ratio of KBr to total volume.	Color test in chloroform.	Color test in carbon disulphide.
n.	10 cm.^{3}	1 : 10000	Strong.	———
	10	1 : 20000	Pronounced.	———
	10	1 : 25000	Pronounced.	Strong.
	10	1 : 33000	Faint.	Pronounced.
	10	1 : 50000	Trace.	Faint.
	10	1 : 100000	Doubtful.	Trace.
	10	1 : 100000	None.	Trace.
	10	1 : 140000	———	Doubtful.
	10	1 : 140000	———	Doubtful.
	5	1 : 12500	Strong.	———
	5	1 : 16000	Strong.	———
	5	1 : 25000	Pronounced.	———
	5	1 : 50000	Trace.	———
	5	1 : 70000	None.	Faint.
	5	1 : 140000	———	Doubtful.

these results it is plain, as Fresenius has pointed out,
white carbon disulphide is the more sensitive reagent,
cy of the test extending distinctly to one part in fifty
when chloroform is the solvent for bromine and to
in one hundred thousand when carbon disulphide is
.

following series of tests the bromide was subjected to
treatment which it must undergo were iodine actually
nd expelled as we proposed. To the solution of the
n a test-tube were added a few drops of dilute sul-
id and a few drops of a solution of potassium nitrite.
id was boiled, cooled, and treated with sodium hy-
e as in the former tests, excepting that even after
r some time it was found to be necessary to introduce
he hypochlorite than before to overcome the nitrous
ining in solution and to set free the bromine.

	Total Volume.	Ratio of KBr to total volume.	Color test in Carbon disulphide.
n.	10 cm.^{3}	1 : 10000	Strong.
	10	1 : 20000	Pronounced.
	10	1 : 25000	Pronounced.
	10	1 : 33000	Faint.
	10	1 : 50000	Faint.
	10	1 : 100000	Doubtful.
	10	1 : 140000	None.
	5	1 : 70000	Trace.

Evidently the presence of nitrous acid and the treatment by boiling do not interfere seriously with the delicacy of the test. The experiments of the following series were made similarly excepting that potassium iodide was added in varying amount to the solution of the bromide. In these tests a spiral of platinum wire was introduced into the test-tube to prevent too violent ebullition, and at intervals during the boiling the nitrite was added in solution, drop by drop, until the iodine was entirely expelled, care being taken to add a little more sulphuric acid toward the end of the separation to ensure completeness of action. The colorlessness of the liquid in the test-tube after this treatment is a fair indication of the entire expulsion of iodine, but when large amounts of bromide are present free bromine will color the liquid. Salts of iron or other substances which possess color naturally interfere likewise. In such cases, and indeed in all cases, the action of the escaping steam upon red litmus paper is decisive. In the experiments here recorded this test was applied to determine the absence of iodine from the liquid. The residue after the expulsion of the iodine was treated as usual with sodium hypochlorite and shaken with carbon disulphide.

KI taken.	KBr taken.	Total Volume.	Ratio of KBr to total volume.	Color in Carbon disulphide.
0·1000 grm.	0·0010 grm.	10 cm.^{3}	1 : 10000	Pronounced.
0·1000	0·0004	10	1 : 25000	Pronounced.
0·1000	0·0003	10	1 : 33000	Pronounced.
0·1000	0·0002	10	1 : 50000	Faint.
0.1000	0·0002	10	1 : 50000	Faint.
0.1000	0·0001	10	1 : 100000	None.
0·0500	0·0005	10	1 : 20000	Pronounced.
0·0400	0·0004	10	1 : 25000	Pronounced.
0·0300	0·0003	10	1 : 33000	Pronounced.
0·0200	0·0002	10	1 : 50000	Faint.
0·0100	0·0001	10	1 : 100000	None.
0·1000	0·00007	5	1 : 70000	Trace.
0·0070	0·00007	5	1 : 70000	Trace.

These results indicate obviously that although the bromine is volatilized to some extent with the iodine it is nevertheless the case that the proportionate amount of bromine removed is dependent upon the absolute amount present, and that enough bromine always remains to permit correct inference as to the quantity originally present, the color test being more or less marked according as much or little bromide was in the solution at the start. The delicacy of the test is a trifle less than that in which the bromide is alone present and not subjected to the treatment which we employ to remove iodine, but the detection of one part of potassium bromide in fifty thousand is certain, and that of one part in seventy thousand possible. It appears, furthermore, that the increase in the amount of iodine present is without effect upon the sensitiveness of the test; for the bromine in 0·00007 grm. of potassium bromide was as found in the residue remaining after the expulsion of dine from 0·1 grm. of potassium iodide as in that left the expulsion of the iodine from 0·0070 grm. of the same nd the indications in the experiments in which the ratio e iodine to the bromine remained the same while the ab- e amounts of both varied are precisely the same as those e experiments in which the maximum amount of iodine ined unchanged throughout the variations in the amount omide used. The maximum amount of potassium iodide oyed in these tests was 0·1 grm., but there is no reason to se that this amount is not far below the maximum which be successfully handled in this process.

r the detection of chlorine we modified the well-known ochromic anhydride process so that the distillation may be rmed in an ordinary test-tube. The substance to be tested solid, placed in a large test-tube—$15^{cm} \times 2^{cm}$ is a good size l treated with sulphuric acid and potassium dichromate in anner to be described. The substance, if a liquid, is ren- l alkaline, if necessary, by sodium carbonate and evapo- to dryness in the test-tube with care to remove all mois- from the sides of the tube. This operation is effected ut trouble if the tube is inclined, as much as is possible ut spilling the liquid, and agitated continually while the is applied to the higher parts. The evaporation effected, e powdered potassium dichromate is introduced through nel with care to prevent its touching the upper parts of be, two or three cubic centimeters of strong sulphuric re added, and a trap consisting of a straight two-bulbed g-tube cut off about an inch from the large bulb is hung e mouth of the test-tube, the precaution having been first to moisten the interior of the bulbs with water without ng the wide, straight portion which hangs within the test- If a chloride is present the evolution of chlorochromic lride begins as soon as this sulphuric acid touches the dry n the bottom of the tube, and gentle heating, with a little ion, quickly completes the evolution of the chlorine com- l. It is the function of the moisture in the bulbs to de- ose the fumes of the chlorochromic anhydride and to re- he chromic acid thus produced. When more than a mere of chlorine is present the yellow drops produced in the ened bulbs are, in the absence of a bromide, sufficiently tive of the presence of chlorine in the original substance, e delicacy of this test is much increased by washing out lbs with a little distilled water and adding to the solu- s Wiley recommends,* a few drops of a solution of lead e, which precipitates the yellow chromate or intensifies lor of the solution according to the amount of chromic acid acting. It often happens, when the temperature of the liquid in the test-tube rises a little higher than need be, that fumes of sulphuric acid pass into the bulbs to such an extent as to produce a white precipitate of lead sulphate when the lead acetate is subsequently added. In such cases the lead sulphate is easily dissolved by the addition of a little ammonic acetate in saturated solution, and gentle heating, and, on cooling, the yellow chromate is either precipitated or simply colors the liquid. It is advisable, however, as our experience proved, not to employ more of the ammonic acetate than the occasion requires, as it undoubtedly exerts some solvent action upon the lead chromate as well as upon the sulphate.

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* Am. Chem. Jour., ii, 248.

We proceeded to test in the manner described the applicability of this process by first testing the action upon solutions of pure potassium chloride.

KCl taken.	Final volume.	Reaction obtained.
0·0030	5$^{cm^3}$	Marked precipitation.
0·0020	5	Marked precipitation.
0·0010	5	Distinct precipitation.
0·0005	5	Distinct color.
0·0004	5	Faint color.
0·0003	5	Faint color.
0·0002	5	Faintest color.
0·0001	5	Doubtful.
0·0001	5	None.
0·0001	5	None.

It appears, therefore, that the chlorine in 0·0005 grm. of potassium chloride is found certainly, and that indications of chlorine in amounts of the chloride ranging as low as 0·0002 grm. are fairly evident in tests made upon the pure substance taken in solution, evaporated, and treated as described.

The effect of submitting the solution of the chloride containing also a known amount of potassium iodide to the process previously described for liberating the iodine, of then neutralizing the solution with sodium carbonate, evaporating to dryness, and treating with sulphuric acid and potassium dichromate, is shown in the following record. The potassium iodide used in these tests was prepared free from chlorine by the action of resublimed iodine upon iron wire and subsequent treatment with pure potassium carbonate. The nitrite was freed from chlorine by adding to its solution a little silver nitrate, faintly acidulating with nitric acid, and filtering off the chloride precipitated with a small amount of the nitrite.

KI taken.	KCl taken.	Final volume.	Reaction obtained.
0·1 grm.	0·0020 grm.	5 cm.^{3}	Distinct precipitation.
0·1	0·0010	5	Distinct color.
0·1	0·0005	5	Faint color.
0·1	0·0004	5	Faint color
0·1	0·0003	5	Faintest color.
0·1	0·0002	5	Faintest color.
0·1	0·0001	5	None.

The distinctness of the color obtained in this process seems to be diminished a little by the process of liberating the iodine, but the lowest reach of the test is not very materially different from that made upon the pure chloride. In the following similar tests made with mixtures containing beside the chloride potassium bromide alone, or the bromide as well as iodide, the phenomena observed were the same, excepting that the fumes of the bromine evolved when much bromide is present rise with the chlorochromic anhydride and, dissolving in the film of moisture in the trap, give to it their own characteristic color, and so obscure the effect of chromic acid. In these experiments, therefore, the washings of the bulbs were first rendered faintly ammoniacal and gently heated to destroy the free bromine, and then the solution was acidified with acetic acid and tested as described with lead acetate and ammonium acetate.

KI taken.	KBr taken.	KCl taken.	Final volume.	Reaction obtained.
—	0·1 grm.	0·0030 grm.	5 cm.^{3}	Marked precipitation.
—	0·1	0·0020	5	Distinct precipitation.
—	0·1	0·0010	5	Distinct color.
—	0·1	0·0005	5	Faint color.
—	0·1	0·0005	5	Faint color.
—	0·1	0·0004	5	Faintest color.
—	0·1	0·0003	5	Doubtful color.
—	0·1	0·0002	5	Doubtful color.
—	0·1	0·0001	5	None.
0·1 grm.	0·1	0·0010	5	Distinct color.
0·1	0·1	0·0010	5	Distinct color.
0·1	0·1	0·0010	5	Distinct color.

The evolution of considerable amounts of bromine appears, therefore, to diminish the delicacy of the test in some degree, but 0·0005 grm. of chlorine—the amount in 0·0010 grm. of potassium chloride—is indicated unmistakably in the presence of 0·1 grm. of potassium bromide, and 0·1 grm. of potassium iodide, and the test may probably be relied upon to show half that amount of chlorine. The potassium iodide, as already mentioned, was specially prepared for the work, and contained in the amounts which we used no recognizable trace of chlorine. The potassium bromide contained of chlorides enough to show an indication in 0·5 grm. of the salt. We were unable to find the chlorine in 0·2 grm. of the salt, and so considered it safe to employ half this latter amount in our experiments as being sufficiently free from chlorine for the purpose.

The process which we propose for the rapid qualitative detection of the halogens in presence of one another may be summarized briefly, as follows:

To detect iodine, the solution of the substance under examination is acidulated with dilute sulphuric acid and treated with a drop or two of a solution of sodium or potassium nitrite free from chlorine. Unless the amount present is small, the iodine shows itself in the color of the solution and in the vapors which escape. Small amounts may be found by shaking the liquid with carbon disulphide in the usual manner, or, when economy of material is desirable, by gently heating the prepared solution and testing the escaping fumes with red litmus paper, thus utilizing the same portion of material for the detection of the iodine and for its separation preparatory to testing for bromine and chlorine.

To remove the iodine previous to making the tests for bromine and chlorine, a few drops of dilute sulphuric acid and a like amount of a dilute solution of sodium or potassium nitrite (prepared free from chlorine as described) are added to the solution of the substance in a test-tube, and the liquid is boiled with constant agitation. When the color of iodine disappears from the fumes and the solution, a drop or two more of sulphuric acid, and of the nitrite, are again added, and the boiling is repeated. When the escaping steam no longer gives to red litmus paper the characteristic gray blue color due to the action of iodine, the process of separation is complete.

A portion of the solution thus prepared is tested for bromine by cautiously adding a dilute solution of sodium hypochlorite and shaking with colorless carbon disulphide.

The test for chlorine is made in a second portion of the solution from which the iodine has been removed. The liquid is neutralized with sodium carbonate or hydrate free from chlorine, evaporated to dryness in a test-tube and treated as described with sulphuric acid and potassium dichromate, the fumes of the chlorochromic anhydride which arise on gentle warming being condensed and converted to chromic acid by the film of moisture upon the interior walls of the trap. The trap is washed out with a very little distilled water (5 cm.' are enough), and the washings made slightly ammoniacal to destroy free bromine, if necessary, and after gentle warming again acidified, are tested with lead acetate. If the yellow chromate is precipitated the presence of chlorine in the original substance is proved. If the precipitate is white, as is very likely to be the case, a few drops of a saturated solution of ammonium acetate are added with caution, and the whole is gently warmed to dissolve the white sulphate. On cooling the solution and shaking (or immediately if much chromic acid has been formed), the yellow chromate falls, or gives color to the solution according as the chloride was originally present in large or small amount.

The process is rapid and sufficiently exact for qualitative testing in general.

RT. XXXVIII.—*Metacinnabarite from New Almaden, California;* by W. H. Melville.

An excellent specimen of metacinnabarite was recently und in the quicksilver mine at New Almaden, Santa Clara unty, California, and a portion of it was given me for exination. Metacinnabarite was never before known to occur these deposits, although in neighboring cinnabar localities e amorphous mineral has been met with. This specimen ries finely developed and brilliant crystals which are admirly adapted for measurement on the goniometer.

In the ore seam where cinnabar has been deposited, there pears an argillaceous mass which has resulted from sediments rived from the decomposition of the country rock by solaric action. This mass is not homogeneous but consists of ay and green particles, the former evidently a mixture of y and partially decomposed rock constituents with a small ount of carbonates, the latter a silicate the composition of ich is shown in the following analysis.

Analysis of the Green Silicate.

SiO_2	67·59
Cr_2O_3	5·31
Al_2O_3 Fe_2O_3	12·24
NiO	4·57
CaO	0·73
MgO	7·84
Alkalies	very little
	98·28

In justice to these figures it should be said that only 0·1225 am of substance could be obtained in sufficient purity for dy, and the little impurity which this sample contained uld not be removed by Thoulet's solution; also alkalies could t be determined.

Throughout this sheet of soft argillaceous matter, or selvage, ge quantities of metallic quicksilver easily seen by the ked eye are distributed, and bright red cinnabar often deeply loring small areas of quartz has crystallized. Cinnabar is und mainly deposited on this selvage—on the specimen at nd about an inch thick—intimately mixed with quartz, thus ming a hard compact mass upon which have grown cinnabar ystals, and these in turn are coated with minute quartz crys-s. To this quartz the acute apex of the metacinnabarite ystal is attached and consequently is always broken. The genesis of this metacinnabarite was certainly subsequent to the deposition of the cinnabar, and groups of flat rhombohedrons of white semi-transparent calcite appear to have formed at the same time. Crystallized dolomite is common among the ores of New Almaden and to this a fibrous silicate, undoubtedly chrysotile, firmly adheres. Fine bluish opal and occasional spangles of pyrite complete the list of associated minerals.

One other brittle substance was discovered while picking out metacinnabarite for analysis. It forms almost perfect spheres of a brilliant black color, which volatilize at a high temperature in yellowish vapor with a strong bituminous odor. The substance is organic matter and curiously mercury does not enter into its composition. These spheres can be detected under the microscope imbedded in the faces of the crystals of metacinnabarite (fig. 2.) and some were obtained by sharply rapping the specimen.

The rather low specific gravity of metacinnabarite is thus accounted for in part. Again the presence of minute particles of quartz was unavoidable, and therefore the given value was also influenced to a slight extent by this cause. The crystals used for the determination of the specific gravity contained far less impurity than is recorded in the analysis which follows. The specific gravity was in two cases 7·095 and 7·142, or mean =7·118 almost identical with that of guadalcazarite, 7·15.

Analysis of Metacinnabarite.

			At. Ratio.	
S	13·68		0·855	
Hg	78·01	S corresponding=12·48 %	0·7801	
Fe	0·61	0·34	0·0218	0·0549
Co	trace		——	
Zn	0·90	0·44	0·0277	
Mn	0·15	0·09	0·0054	
$CaCO_3$	0·71	13.35		
Residue, quartz	4·57	S found 13·68		
Volatile organic matter	0·63			
	99·26			

For analysis 0·6237 gram of substance was available, and both the qualitative and quantitative study proceeded contemporaneously. The small errors of analysis are distributed between the sulphur and organic matter, where the sulphur is as usual a trifle too high An uncertainty naturally exists in the determination of the organic matter. Selenium was looked for but its presence failed to be established.

The crystals belong to the rhombohedral system (Miller) and consist of two poles differently modified. The following forms were observed :

Analogue Pole.

	Miller.	Bravais-Miller. $(h\ k\ l\ m)$	Naumann.
plane..................	$\kappa(111)$	$\kappa(0001)$	$c : \infty a : \infty a : \infty a$
ve hemi-rhombohedron ...	$\kappa(100)$	$\kappa(1\bar{1}01)$	$c : a : a : \infty a$
tive rhombohedron	$\kappa(33\bar{2})$	$\kappa(0\bar{5}54)$	$\frac{5}{4}c : \infty : 1 : 1$
-scalenohedron..	$\kappa(21\bar{1})$	$\kappa(1\bar{3}22)$	$\frac{3}{2}c : 3 : 1 : \frac{3}{2}$

Antilogue Pole.

tive hemi-rhombohedron...	$\kappa(33, \bar{1}\bar{7}, \bar{1}\bar{7},)$	$\kappa(50, \bar{5}\bar{0}, 0, \bar{1})$	$50c : 1 : 1 : \infty$
-scalenohedron.............	$\kappa(31, \bar{1}\bar{7}, \bar{1}\bar{5})$	$\kappa(48, \bar{4}\bar{6}, \bar{2}, \bar{1})$	$48c : 1 : \frac{24}{23} : 24$
-scalenohedron.............	$\kappa(26. \bar{1}\bar{5}, \bar{1}\bar{2})$	$\kappa(41. \bar{3}\bar{8}, \bar{3}, \bar{1})$	$41c : 1 : \frac{41}{38} ; \frac{41}{3}$

gle of axes (Miller) = 118° 11′ 20″
ial ratio $c : a = 0{\cdot}2372 : 1$ (Naumann).

Measurements.

	Measured.	Calculated.
$111 \wedge 100 =$	15° 19′	
$100 \wedge 010$	26 29	
$100 \wedge 21\bar{1}$	4 16	
$111 \wedge 33, \bar{1}\bar{7}, \bar{1}\bar{7}$	94 10	94° 10′ 36″
$111 \wedge 31, \bar{1}\bar{7}, \bar{1}\bar{5}$	94 31	94 33
$111 \wedge 26, \bar{1}\bar{5}, \bar{1}\bar{2}$	94 42	95 17
$33, \bar{1}\bar{7}, \bar{1}\bar{7} \wedge \bar{1}\bar{7}, 33, \bar{1}\bar{7}$	119 28	119 28
$33, \bar{1}\bar{7}, \bar{1}\bar{7} \wedge 31, \bar{1}\bar{7}, \bar{1}\bar{5}$	2 6	
$33, \bar{1}\bar{7}, \bar{1}\bar{7} \wedge 26, \bar{1}\bar{5}, 12$	3 55	

Fig. 1.

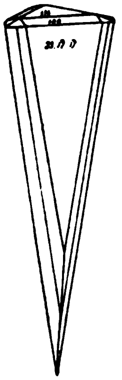
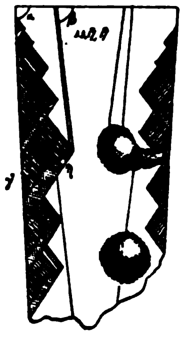


Fig. 2.



he poles of the scalenohe-ns in the negative hemi-ere almost belong in the zone les passing through any two es of the negative rhombo-ron, therefore, as shown in figures the planes of the for- do not exactly bevel the ninal edges of the latter. e faces of the former , $\bar{1}\bar{5}, \bar{1}\bar{2}$) are tectonic and con- series of re-entering angles 2) which indicate the build- up of that portion of the stal rather than twinning. erwise striations are absent, and owing to the brilliancy of plane surfaces sharp reflections of the signals on the goni-ter were obtained. Fig. 2 was drawn with the aid of s-hair and graduated stage of the microscope and in such tion that the face ($33, \bar{1}\bar{7}, \bar{1}\bar{7}$) is parallel to the plane of pro-ion. The following plane angles were read: $\alpha = 86°\ 20'$, 32°45, $\gamma = 39$, $\delta = 85°\ 30'$, $\eta = 24°$. The relations of these les with the elements of the crystal have not been made

With the exception of $\kappa(33\bar{2})$ all the observed forms are represented in fig. 1, and actually occur on one crystal with equal regularity. Fig. 2 is the combination of $x(111)$ with the plains of the antilogue pole tabulated above. The distances of the poles of all the rhombohedral faces from the pole of (111) were measured on the same crystals and no doubt can possibly exist as to the system of crystallization. Viewed as they are implanted on the rock, the crystals present much similarity to tetrahedrons, but examination shows that the face of the negative rhombohedron in combination with the basal plane forms an isosceles and not an equilateral triangle. Besides the measured angle $\beta = 82° 45'$ the plane acute angle of $(33, \bar{1}\bar{7}, \bar{1}\bar{7}) = 14° 29' 40''$ was calculated from the fundamental angles. The crystals vary in length from $1{\cdot}24^{mm}$ to $2{\cdot}3^{mm}$ and in width from $0{\cdot}59^{mm}$ to $0{\cdot}97^{mm}$; possess a high metallic luster, black color, black streak with slight reddish tinge; are brittle with hardness about 2; and give the reactions for zinc and sulphide of mercury.

This mineral I consider metacinnabarite since the atomic ratios give a very improbable formula. Its specific gravity is much below that given to the species by Mr. G. E. Moore* $7{\cdot}70-7{\cdot}75$ for the reasons stated above. On the other hand its somewhat close resemblance to guadalcazarite† in chemical and physical properties—for Castillo mentions rhombohedral crystals of this mineral—might point to its identity with this species. But it must be acknowledged to be metacinnabarite in composition with a small percentage of impurity of other sulphides such as would be naturally expected on precipitation and crystallization from solution. Again the crystals of metacinnabarite, many of which I have examined from localities in California as far back as 1882, are very indefinite and although they appear to be rough cubo-octahedrons, might really consist of the combination of basal plane and rhombohedron. Mr. S. L. Penfield‡ has described metacinnabarite crystals from California, and determines them to be hemihedral isometric forms. One measurement is there given, viz: $322 \wedge 3\bar{2}\bar{2} = 86° 54\tfrac{1}{8}'$ (mean of three) which approximates the angle $(\bar{1}\bar{1}\bar{1}) \wedge (33, \bar{1}\bar{7}, \bar{1}\bar{7}) = 85° 50'$, the supplement of which appears in the table above. It is possible that these two planes may form the combination I have indicated. No angle occurs on crystals in my possession near that of $211 \wedge 112 = 33° 15'$ to $36° 54'$ which Mr. Penfield found. It is barely probable that metacinnabarite is dimorphous. If it should happen that brilliant crystals of metacinnabarite from the Knoxville quicksilver district should be found, I firmly believe that their habit

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[*] Dana's Mineralogy, App. I, 10.

[†] Ibid, App. II. 25.

[‡] This Journal, June, 1885, p. 452.

d be reconciled with the symmetry of the crystals from v Almaden, the southern district.

is through the kindness of Mr. Waldemar Lindgren of U. S. Geological Survey and Mr. F. Von Leicht, the super- ndent of the New Almaden quicksilver mines, that the erial was available for this study.

boratory U. S. Geological Survey, Washington, D. C., June, 1890.

r. XXXIX.—*On the Keokuk Beds at Keokuk, Iowa;* by C. H. Gordon.

HE exposed area of the Keokuk Beds is nowhere extensive. ir relations to the adjoining beds—the Burlington below the St. Louis above—are everywhere marked by strict formity, their separation being based solely upon lithologi- and faunal distinctions. Of these, the faunal characteris- especially are of such a nature as to mark this formation one of the most important of the Lower Carboniferous up. The exposure at Keokuk is limited, being entirely due he erosion of the Mississippi river and its small tributaries. ng the borders of these the limestone of the lower division ally presents a bold and smooth escarpment.

utside of the Keokuk region where the beds were first lied, the most notable exposures occur at Crawfordsville, iana, and in southwestern Missouri. At the former locality y are 280 feet thick with a distinctively crinoidal and mol- an fauna.* In Missouri they contain valuable deposits of l.

he general dip toward the south and west carries these beds n sight just below the mouth of the Des Moines, but a nge of dip again brings them to view in the vicinity of ncy, Ill., and at other places to the south. In some cases ir appearance is due to faulting.

t Keokuk these beds consist of two well-defined divisions he Lower or Calcareous and the Upper or Geode division.

II. *Geode Bed or Division.*

Fine, blue sandy layer. Crinoid bed No. 3. Resembles the arenaceous layers of the crinoid bed at Crawfordsville, Ind. *Seldom seen. Seventeen species of Poteriocrinidæ, Batocrinus laguncalus* Hall, *B. intermedius* W. and S., *B. similis* Hall, *B. originarius* W. and S., *B. mundulus* Hall, *Taxocrinus Wortheni* Hall. Thickness .... 6 in.

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* American Geologist, vol. ii, p. 407.

12. Soft, gritty shale, readily decomposing on exposure to atmospheric influences. Filled with geodes varying in size from one to four inches in diameter. Thickness..15 ft.

11. Shales, more calcareous, with occasional bands of limestone. Geodes fewer but larger. Thickness ....20 ft.

10. Limestone, hard, in thin variable layers. Thickness .... 2 ft.

9. Dark blue argillaceous shale. Contains no geodes Thickness .... 2 ft.

I. *Calcareous Division.*

8. Limestone, light gray, changing to light brown or yellow on exposure. Crinoid bed No. 2, sometimes called the Dorycrinus bed. *Batocrinus Nashvillæ* Troost, *B. biturbinatus* Hall, *Dorycrinus Mississippiensis* Rœmer, *Agaricocrinus Wortheni* Hall. *A. Americanus*, var. ——? *Barrycrinus tumidus* Hall, *Archimedes Oweniana* Hall, etc. Thickness ....1 to 2 ft.

Lenticular layers, prolific in crinoids, are sometimes found intercalated between 7 *and* 8.

7. Hard blue limestone; layers thin. Thickness.......3 to 5 ft.

6. Heavy dark blue limestone with nodules of chert. Fish bed No. 2. Thickness.........................2 to 4 ft.

5. Blue subcrystalline limestone in layers 6 to 12 inches thick, alternating with similar layers of shales. Single valves and casts of *Spirifer Keokuk* Hall, abundant. Thickness...................................8 to 15 ft.

4. White or light gray massive limestone called White Ledge by the quarrymen. Fish bed No. 1. Thickness. 4 ft.

At this point the partings frequently contain crinoids, while in some places a thin crinoidal layer is found resting upon the rolling cherty surface of the layer below. *Actinocrinus*, *Agaricocrinus Americanus* Rœmer, *Barycrinus magister* Hall, etc.

3. Impure shaly limestone with occasional bands of chert. Contains pockets of calcite in large beautiful crystals. Thickness .... 6 ft.

2. Light gray comparatively soft limestone. Crinoid bed No. 1. Species numerous. *Agaricocrinus Americanus* Rœmer, also two varieties. *Actinocrinus pernodosus* Hall, *A. Lowei* Hall, *Batocrinus laguncula* Hall, *Platycrinus Saffordi*. Thickness.............6 in. to 1 ft.

1. Massive blue or drab subcrystalline limestone. Occasional specimens of fish teeth belonging to the genus *Chitonodus*. Thickness.......................... 3 ft.

The parting between this and the beds below filled with stems and joints of *Eucladocrinus*.

Transition Beds.

Limestone in thin layers; cherty. Thickness exposed 6 ft. *Platyceras fissurella* Hall, *P. equilatera* Hall, *Palæcis obtusus* M. and W., *Batocrinus planodiscus* H., etc.

The Calcareous division consists of forty to sixty feet of imestone in layers varying from three inches to four feet, and eparated by one to six inches of clay or shale partings. The hicker beds and those furnishing the best building stone ccur in the lower portions of the division. One of these (No. 4), a very pure white. subcrystalline layer from three to four eet thick, called the White Ledge by the quarrymen, supplied he stone for the noted Mormon temple at Nauvoo. Another ower bed, separated from the White Ledge by six feet of hale and rotten limestone, sometimes furnishes an equally ood if not better stone for general use. Below this the layers f the transition beds are thin and abound in chert.

Cherty bands occur at various intervals throughout the ivision. They have a concretionary structure, and vary in olor from a dark drab to white, though usually more or less ottled. They are sometimes quite prominently discolored y included fossil fragments. The limestone layers often ecome cherty above with an uneven rolling surface. The ore important chert masses have the general appearance of a edimentary deposit. Nodular masses, however, frequently ccur in various forms in the limestone beds. In some cases he siliceous material is distributed about some fossil fragment. n others they present the appearance of having taken the lace of a cavity in the stone. The surface of contact is often istinct, the chert separating freely from the limestone, but djacent parts of the latter are more or less altered to a cherty ondition. These nodules have an eel-like form with often ne or more bends and are not always parallel to the plane of edding. A section shows a mottled, grayish white chert on he outside distributed in bands about an inner core of granuar material made up principally of fossil fragments in a cominuted condition.

The chert beds, aggregating forty feet, which immediately nderlie this division were included in it in Hall's Report* but ubsequently removed to the Burlington by White.†

The appearance of these bands of chert at varying interals from the Lower Burlington to the St. Louis limestone nclusive has been commented upon by White, though no xplanation of their origin has been attempted.‡ Worthen attributed them to the intrusion of water charged with siliceous material from below. The accession of siliceous material to the waters of that epoch, however caused, resulted in the more or less complete extermination of the life characterizing the preceding epoch. Upon the restoration of normal conditions, however, a profusion of forms again appears though marked by variations in type and form. This tendency toward extinction may be observed in the smaller as well as the more important chert beds. The crinoidal facies of the first crinoid bed is essentially different from that of the second, while that of the third is unlike either. The destructive effect of excess of siliceous material represented in the Geode bed is especially noticeable in the paucity of species that were able to survive it. The almost complete extinction of the Actinocrinidæ is especially remarkable.* Not only is this true of crinoidal life but it has been remarked that a profusion of fish remains is nearly always accompanied by greater or less quantities of chert. The obvious connection existing between the presence of the chert and the extinction of previously existing species is certainly of great interest both from dynamical and evolutionary standpoints, though at present little understood.

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* Geological Survey of Iowa, 1858, vol. i, part 1, p. 94.

† Geological Survey of Iowa, 1870, vol. i, p. 203 (note).

‡ The investigations of G. I Hinde, of the British Museum, on various cherts ver the world led him to the conclusion that they are of organic origin. "The hert from the Carboniferous limestones of Ireland was all made chiefly from the iliceous spicules of sponges and the silica of silicified fossils has the same source." -This Journal, III, xxxiv, 405. See also vol. xxxvi, 73. Dr. M. C. White, of ew Haven, made the earliest observations upon chert of the "Subcarboniferous imestone of Illinois," and the hornstone of the Corniferous and Black River beds. is paper will be found in this Journal (1862) II, xxxiii, 385. Dana also disusses the subject in his Manual on pages 267, 261, and 305.

At some of the partings in this division the upper surface of the lower stratum shows decided evidences of erosion. The limestone matrix has in some cases been worn away, leaving the fossils projecting one-half to one inch above the general surface. The rock-surface is usually, in these cases, much discolored and altogether its appearance seems to indicate changing submarine currents.

The upper division or Geode bed consists principally of argillaceous shale varying to an impure shaly magnesian limestone. The lower portion is more calcareous, sometimes including thin layers of tolerably pure limestone. An abundance of siliceous matters occurs here in the form of goedes which, with the exception of a few feet in the lower part, are disseminated throughout the formation. They are generally smaller and thicker in the middle and upper portions of the bed, while in the more calcareous layers below the geodes are large and contain more perfectly formed crystals.

The formation contains three crinoid beds quite clearly distinguished from each other in the character of their forms. Outside of these horizons crinoids sometimes occur, but sparingly.

The third bed, No. 13, of the section has not been found outside of a single locality in the lower part of the city discovered by Mr. L. A. Cox. Most of the species obtained from this bed were new and belong to the Poteriocrinidæ, cridently allying this stratum with the crinoid bed at Crawfordsville, Ind., while the resemblance is still further enhanced by the lithological character of the stratum. At the above locality there are twenty-five feet of fossiliferous shale underlying the crinoid beds and followed downward by two hundred feet of limstone and shale.* Now while at Crawfordsville the beds are marked by the Poteriocrinidæ, at Keokuk the fauna of the lower division is essentially Actinocrinoidal in aspect. The most common forms occurring in the lower division at Keokuk, viz: *Batocrinus Nashvillæ*, *B. biturbinatus*, *Actinocrinus pernodosus* and *Agaricocrinus Wortheni*, are absent at Crawfordsville, while even the ubiquitous *Agaricocrinus Americanus* is not recognized in the corrected lists of fossils from that locality.

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* Keyes, American Naturalist, March, 1890, p. 243.

We are disposed therefore to consider it as not improbable that the crinoid beds at Crawfordsville and the associated shale are the stratigraphical equivalent of the Geode bed and its associated layers at Keokuk.

The second crinoid bed is known as the Dorycrinus Bed, from the abundance of a single species of that genus, *D. Mississippiensis*.

The interest attaching to these beds centers largely in their Radiates of which the Crinoidea are the most prominent. The following table gives approximately the genera and number of species and their relations at Keokuk and Crawfordsville:

Genera.	Total Species.	At Keokuk.	At Crawfordsville.	Species common.
Actinocrinus,	6	5	..	
Agaricocrinus,	6	3	1	
Batocrinus,	13	7	2	*B. Indianensis.*
Barrycrinus,	15	9	2	
Calceocrinus,	4	2	1	
Catillocrinus,	2	..	1	
Cyathocrinus,	11	2	5	
Decadocrinus,	2	1	1	
Dichocrinus,	5	3	2	*D. ficus.*
Dorycrinus,	4	4	..	
Eretmocrinus,	5	3	..	
Eucladocrinus,	1	1	..	
Eupachycrinus,	1	1	..	
Forbesiocrinus,	2	1	1	*F. Wortheni.*
Goniasteroidocrinus,	2	1	1	
Graphiocrinus,	1	..	..	
Onychocrinus,	3	1	2	*O. ramulosus.*
Parisocrinus,	1	1	..	
Platycrinus,	5	4	1	*P. hemisphericus.*
Poteriocrinus,	3	1	1	
Rhodocrinus,	1	1	..	
Scaphiocrinus,	16	12	4	
Scytalocrinus,	4	..	3	
Stemmatocrinus,	1	..	..	

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* Beachler, Am. Geol., vol. ii, p. 407.

Genera.	Total Species.	At Keokuk.	At Crawfordsville.	Species common.
Symbathocrinus.	3	3	--	
Taxocrinus,	3	2	1	
Vasocrinus,	1	--	1	
Woodocrinus,	6	3	2	
Zeacrinus,	1	--	--	
Number genera, 29	128	69	32	5

From this it appears that over one-half of the species of the formation occur at Keokuk, while at Crawfordsville the proportion is about one-fourth with only five species common. Out of the sixty-nine species observed at Keokuk, however, a large portion are rarely met with, while the hardness of the limestone matrix renders the collection and cleaning of fossils a comparatively slow and difficult process.

The collection of fish remains made here is an extensive one and may be grouped as follows:

	Total Species.	Species at Keokuk.		Total Species.	Species at Keokuk.
Cochliodonts,	26	20	Psammodonts,	1	1
Hybodonts,	17	17	Ichthyodorulites,	16	13
Petalodonts,	20	14		—	—
			Total,	80	65

It is generally maintained against the evidence for the contrary from Coral Islands, as illustrated by Professor Dana, that limestone is a deep-sea deposit. The appearance of the Keokuk limestone in places shows very decided evidences of having been subjected to shallow water conditions. That littoral conditions are productive of arenaceous deposits alone would seem to necessitate the further proof that the debris derived from the neighboring land surface is distinctively arenaceous in character. That this is generally so is readily seen, but that it is always so can hardly be admitted. The presence of crinoids in the Keokuk limestone has been accepted as conclusive of a deep water origin, since existing forms of this order are usually obtained far below the surface. Nevertheless we are disposed to consider the Keokuk beds in the vicinity of Keokuk as essentially a shallow water deposit. Toward the east where it impinges upon the Cincinnati axis it becomes decidedly arenaceous, but along its northern border in Iowa no such change is observed, its calcareous character being as marked as farther toward the south. Moreover the discovery of a piece of fossil wood in this formation at Keokuk would seem to imply (1) an adjacent shore line and (2) shallow water. This interesting specimen was obtained from No. 5, about 10 feet below the base of the Geode bed. It is a portion of a Sigillarian trunk.

Keokuk, Iowa.

ART. XL.—*Note on the vapor-tension of Sulphuric Acid, with the description of an accurate Cathetometer Microscope;* by CHAS. A. PERKINS, Ph.D., Associate in Physics, Bryn Mawr College.

IN the physical laboratory it is frequently necessary to measure small differences in the height of two objects, such as two columns of liquid, etc., and especially to measure changes of height; and several forms of apparatus have been designed for this work. The cathetometer is accurate for this purpose only when provided with two telescopes and when the objects to be measured are in the same vertical line, and then is not readily used if the points are less than about $10^{\rm cm}$ apart Desiring to make some measurements of this nature, I made use of the following apparatus: A microscope of rather long focus is mounted upon a rigid vertical brass column and is carried by a vertical micrometer screw, reading to $\frac{1}{200}^{\rm mm}$. Immediately in front of the object glass and covering one-half of it, is placed a small total reflecting prism, so adjusted that when the microscope is focussed upon one object, the prism throws into the field the image of an object vertically above or below the second, but on a level with the first. If the objects to be measured are situated upon the same level, they will thus be superimposed; if not at the same level, they will come successively to the center of the field, by moving the micrometer through the necessary distance. With this apparatus, measurements may be made in which the probable error of a single setting is considerably less than $\frac{1}{200}^{\rm mm}$ and in which the motion is a simple vertical one as if the two objects were in the same vertical line. The principal difficulty encountered is to bring both objects into focus at the center of the field. For this it is desirable to have one of the objects movable and to perform the adjustment by moving this object, but it is quite possible to make the adjustment when the objects are connected, as the two legs of a U-tube.

I have made use of this apparatus to measure the vapor tension of sulphuric acid. This liquid has some properties fitting it to be used in pressure gauges, either by itself or in connection with mercury.[*] I desired to use it for this purpose in a place where its vapor tension if appreciable would be injurious.

The only experiment, so far as I know, upon the vapor tension, was made under the direction of Sir Wm. Thomson, and consisted in proving that the tension does not change much between 20° and 100° C.: the column of acid, by which the change of tension was measured, being 3^{mm} in diameter and terminated at one end by a vacuum and at the other by a bulb of gas which was kept as nearly as possible at the same temperature while the acid at the vacuum end of the tube was heated.*

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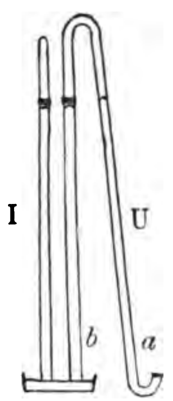
[*] Callendar, On the practical measurement of Temperature. Phil. Trans., vol. clxxviii, p. 161; and Bottomley, On a practical Air Thermometer with constant volume, Phil. Mag., ser. V, vol. xxvi, p. 149.

My own plan originally was to take a U-tube, half filled with mercury, and after drying and exhausting the air from both legs, to observe the depression of mercury in one leg, when a drop of acid was introduced. In every case an elevation was observed, due to moisture leaking in through the cocks, or remaining on the glass and evaporating as exhaustion advanced; a form was therefore adopted which was free from cocks and in which the mercury could be boiled to drive off all moisture. It consists of two barometers. One is an ordinary cistern barometer (I), the other is an inverted U-tube with mercury in both legs. One end (*b*) dips into the same vessel as the tube I, the other (*a*) is recurved to prevent the admission of air, but allowing the acid to be introduced by a curved pipette or medicine dropper. The height of the column (*b*) in U is compared with that in I, before and after admitting acid into U through *a*. The internal diameter of the tubes is about 0·8^{cm}. In filling the U-tube, it is exhausted by a Sprengel pump and heated strongly. When cool, a little mercury is introduced and boiled and this operation is repeated till the tube is full. Unless this precaution is taken, the acid in rising through the tube, carries up air, which causes a depression of the mercury.



The acid was purchased of Queen & Co. as pure concentrated acid, but not absolutely anhydrous.

In making the measurements from three to five readings were made of the position of the meniscus in U and the same number for I: then acid was introduced into the other leg of U and the readings were repeated in the same order. The mercury column is illuminated from behind and a ring of black paper, sliding on the tube, is adjusted as near as possible to the top of the meniscus, allowing only a thread of light to pass over the top of the column. Unless this is done, reflections will make the top of the column uncertain. Where it is possible, the method of using the image of a black point and ts reflection, as done at Breteuil, leaves nothing to be desired; ut I could not work with large enough tubes, and errors of tting were not my principal errors.

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* Encyc. Brit., 9th ed., Article "Heat."

Measured in this way, my three best measurements gave for he vapor tension:

Difference of U and I in 200ths ^{mm}.		
Before admitting acid.	After.	Difference in ^{mm}.
31	33	+·01
9	11	+·01
−12	−13	−·005

This result is considered to be purely negative, as errors due to the change of the height of the barometer during the experiment and those introduced by irregularities in the capillarity of the mercury (in spite of shaking the tube) would be sufficient to account for the measured tension. A larger tube would have avoided some of the trouble, but would have increased very much the labor of manipulation.

In several other experiments, attention was carefully fixed upon the top of the mercury column in the tube *b* just as the acid rose through the other tube (*a*), in order to observe any instantaneous movement of the column. The movement, if any, was very slight—certainly not in excess of the above measurements. I therefore conclude that the tension is not greater than about ·01^{mm}.

ART. XLI.—*Experiments upon the Constitution of the Natural Silicates*; by F. W. CLARKE and E. A. SCHNEIDER.

DURING the past six years the constitution of the natural silicates has received a good deal of attention in the laboratory f the United States Geological Survey. A number of papers ave been published by one of us, partly theoretical and partly nalytical; but the evidence so far considered has been drawn nly from careful analyses of various minerals, and a study of heir obvious relations, their associations, and their alteration roducts. Within certain limits the results obtained have been atisfactory and suggestive; but in several cases it was found hat ordinary analysis failed to discriminate between possible lternative formulæ; and it was plain that the uncertainties ould only be cleared up by new lines of experimental investiation. With such investigations the present paper has to do. ixteen minerals, including varieties, all of the magnesian roup, have been examined; and it has been found quite posible to separate some of them into distinct fractions of definite character in such a way as to shed much light upon their inner chemical structure. In general, the methods which have been employed by us are not new, except in their application to the silicate problem; but in their analogies to the processes used for the elucidation of organic compounds, we believe that they will be found interesting.

In brief, our mode of procedure has been as follows: First, each mineral, selected and purified with great care, has been completely analyzed; and in each case enough material was ground to a uniform sample to suffice for all subsequent experiments. Secondly, each mineral has been subjected to the action of *dry* hydrochloric acid gas, under quantitative conditions. For this purpose a quantity of material was weighed out in a platinum boat, which was then placed in a glass tube and heated in a stream of the dry gas until, after repeated weighings, constant weight was attained. The sample was then treated with water and a drop or two of nitric acid, and the soluble constituents of the mass were determined by the usual methods of analysis. In every instance a sample was thus treated at a temperature between 383° and 412° C., but in some cases other temperatures were studied also. For heating the tubes an ordinary combustion furnace was used; and the temperature was kept within the indicated range by placing on one side of the platinum boat a sealed capillary tube containing lead iodide, melting point 383°, and on the other side a tube containing zinc, which fuses at 412°. The flames of the furnace were then so adjusted that the iodide fused, while the zinc did not. For a higher range of temperatures, which was employed in some cases, the indicators similarly used were lead chloride, m. p 498°, and silver iodide, m. p. 527°. These melting points are given according to Carnelley. As a rule, in each series of experiments the sample under treatment was weighed every two hours; and before reheating it was stirred with a fine platinum wire in order to expose a fresh surface to the action of the acid. By this mode of treatment different minerals are very differently affected; there being almost no action in some cases, and very notable action in others. With this action of gaseous acid, the action of aqueous hydrochloric acid upon each mineral was carefully compared, and some points of great importance were thus brought out. As a rule, one gram of mineral was treated with 75 cc. of fuming hydrochloric acid on the water bath, and the mixture was evaporated to dryness. When decomposition was not complete, the mineral was further treated with hydrochloric acid of sp. gr. 1·12 for three days or even longer, and the amount of action was ascertained and recorded. In several instances this treatment with aqueous acid was repeated after strong ignition of a mineral, and it was sometimes found that a species previously soluble could be thus split up into a soluble and an insoluble part. In a number of cases ignition of a mineral caused the liberation of silica, which could afterwards be dissolved out with soda solution and quantitatively determined. For this purpose a solution of sodium carbonate, 250 grams to the liter, was employed. Finally, in almost every case the nature of the water in a mineral was investigated, by a study of the temperatures at which its several fractions were expelled. For low temperatures, an ordinary air-bath was used; for higher temperatures the minerals were heated in a stream of dry air, between indicators of known melting points, just as in the treatment with gaseous hydrochloric acid.

So much for the methods of research, which will be more clearly understood from a study of the details to be given presently. On the theoretical side we have adhered to the working hypothesis that the more complex silicates are substitution derivatives of normal salts, as has been suggested by one of us in several earlier publications. From this point of view the normal ortho-silicate of magnesium is the fittest starting point for discussion, and this salt is approximately represented by olivine. The purer forsterite was not available.

1. *Olivine.*

For this species the only material at hand was a supply of the chrysolite pebbles from near Fort Wingate, New Mexico. The mineral from this locality, we believe, has not been previously analyzed; and as it is rich enough in color and is sufficiently clear it is often cut as a gem. It has the characteristic color of the peridot, and is apparently quite free from inclusions. The analysis gave the following results:

SiO_2	41·98
Fe_2O_3	·51
FeO	5·71
NiO	·42
MnO	·10
MgO	51·11
H_2O	·28
	100·11

Only 0·05 per cent of the water was lost at 105°.

1·1027 grams of the mineral were heated in gaseous hydrochloric acid for twenty-two hours, and gained in weight 0·0157 grm. On leaching with water and a drop of nitric acid the following percentages of material went into solution:

MgO	1·47
Fe_2O_3	·43

Hence olivine, at the temperature of 383°–412°, is hardly attacked by dry hydrochloric acid; and the slight action here recorded may possibly be due to incomplete drying of the gas. The aqueous acid, on the other hand, decomposes olivine with great ease. On this mineral no other experiments were necessary for our purposes.

2. *Talc.*

The mineral studied was a typical, apple-green, foliated talc from Hunter's Mill, Fairfax County, Virginia. Analysis as follows:

SiO_2	62·27
Al_2O_3	·15
Fe_2O_3	·95
MgO	30·95
FeO	·85
MnO	trace
H_2O	4·91
	100·08

In detail, the water determination was as follows:

Loss at 105°	·07
Loss at 250°–300°	·06
Loss at red heat	4·43
Loss at white heat	·35

Hence the water is practically all constitutional.

Heated in dry HCl gas to 383°–412° for fifteen hours, the talc underwent inappreciable change of weight. Upon leaching, only 0·23 per cent of magnesia went into solution. By rapid evaporation with 75 cc. of fuming aqueous HCl, 1·05 per cent of MgO and 0·16 of $(FeAl)_2O_3$ were dissolved. Upon eight days' digestion on the water bath with acid of 1·12 sp. gr., 1·94 MgO and 0·23 of sesquioxides were removed. By digesting in like manner for thirty-two days, 3·94 MgO and 0·41 of sesquioxides were taken out. Talc, therefore, is, as should have been expected, remarkably stable in presence of hydrochloric acid, both aqueous and dry. This fact has a very important bearing upon the constitutional formula of the mineral.

In empirical composition the talc analyzed agrees quite sharply with the accepted formula $Mg_3H_2Si_4O_{12}$. This is commonly interpreted as an acid metasilicate, $Mg_3H_2(SiO_3)_4$; but Groth has lately proposed to consider talc as a basic salt of pyrosilicic acid, $H_2Si_2O_5$. On this supposition its rational formula becomes $Mg(Si_2O_5)_2(MgOH)_2$. Between these two formulæ, experiment is able to decide.

Against Groth's formula the stability of talc towards acids tells very strongly. The univalent group — Mg — OH ought to be soluble in hydrochloric acid; and evidence, to be presented later, goes to show that that particular group is easily removable by the dry, gaseous HCl. In fact, our experiments make it highly probable that all the magnesia taken from a silicate by perfectly dry HCl, was originally present in the hydroxylated form. As regards the constitution of talc, however, other evidence is even stronger.

If Groth's formula is correct, then, upon ignition, talc should behave according to the equation

$$Mg<\begin{matrix}Si_2O_6—Mg—OH\\Si_2O_6—Mg—OH\end{matrix}—H_2O = Mg<\begin{matrix}Si_2O_6—Mg\\Si_2O_6—Mg\end{matrix}>O.$$

In other words the loss of water should produce but little change, and no silica should be liberated. If, on the other hand, the acid metasilicate formula is true, talc should split up into $3MgSiO_3+SiO_2+H_2O$; that is, one-fourth of the silica should be set free; which, in the present instance, would amount to 15·57 per cent. This actually happens; and a weighed quantity of talc, ignited very intensely for half an hour over a blast-lamp, gave up 15·36 per cent of SiO_2 upon subsequent boiling with a solution of sodium carbonate. Upon longer ignition, as might be expected, a part of this silica reverts to the insoluble form, and somewhat lower results are obtained. Upon the unignited talc, boiling with soda solution for twenty-four hours produced little or no effect; soda was not taken up, nor was silica removed.

In brief, both lines of evidence, the liberation of silica and the stability toward acids, confirm the ordinary formula for talc and controvert the views of Groth; and no other formula out of several which are possible, satisfies both of the experimentally established conditions. The mineral, therefore, must be regarded as an acid metasilicate; although its ultimate structural formula can be written only when we have a better knowledge of metasilicic acid. It is a noteworthy fact, that no normal metasilicic ether is yet certainly known; for Ebelmen's results have not been confirmed by later observers. Troost and Hautefeuille, however, prepared an ether having the composition $(C_2H_5)_8Si_4O_{12}$. Possibly enstatite may be the normal magnesium salt corresponding to this ether; in which case talc would be a substitution derivative having H_2 in place of one atom of Mg.

3. *Serpentine.*

On account of the importance of this species, its variability in external characteristics, and its manifold relations to other minerals, several distinct samples were investigated.

A. Dull-green serpentine from Montville, New Jersey, derived from pyroxene by alteration.

B. Dark-green serpentine from the well-known locality at Newburyport, Massachusetts.

C. Silky, fibrous chrysotile from Montville.

D. Grayish-green picrolite from Buck Creek, North Carolina.

E. A grayish green mineral from Corundum Hill, North Carolina, which was supposed at first to be deweylite. It is an ordinary, massive serpentine.

Analyses as follows, with the itemized water determinations subjoined.

	A	B	C	D	E
SiO_2	42·05	41·47	42·12	42·94	41·90
H_2O	14·66	15·06	15·64	13·21	16·16
MgO	42·57	41·70	41·01	36·53	40·16
FeO	·10	·09	undet.	1·88	undet.
CaO	·05	none	trace	----	----
NiO	----	----	·23	·61	·10
Fe_2O_3	·30	1·73	·62	3·33	·91
Al_2O_3	----		·63	1·72	·71
	99·73	100·05	100·55	100·22	99·94

	A	B	C	D	E
H_2O at 105°	·96	1·20	2·04	1·53	2·26
H_2O at 250°	·55	·55	·71	·44	1·01
H_2O at 383°–412° ..	·27	----	·27	·62	·98
H_2O at 498°–527° ..	·23	----	·56	----	·42
H_2O at red heat....	12·37	13·01	11·81	10·58	11·32
H_2O at white heat..	·28	·30	·25	·04	·17

From these data it is clear that practically all the water in serpentine is constitutional, and that none of it can be fairly regarded as crystalline. The small, variable amount lost below 250° is mainly hygroscopic and enclosed water, since the analyses refer to air-dried material. It is hardly necessary to state that in each fractional determination the material was heated to constant weight.

Upon heating in dry, gaseous, hydrochloric acid all of these serpentines were strongly attacked; differing essentially in this particular from olivine and talc. The bases thus taken out as chlorides at 383°–412° were as follows:

	A	B	C	D	E
No. of hours heated....	54	68	54	78	41
MgO extracted	10·14	16·73	9·98	11·38	15·25
R_2O_3 extracted	----	·43	----	·66	·51

In the last determination the soluble magnesia was accidentally lost; and the value given was estimated by difference. A duplicate determination on the Newburyport mineral, at the same temperature, with 39 hours' heating gave only 14·43 per cent of magnesia removed as chloride. The different times required for obtaining constant weight and so fixing the limit of the reaction vary considerably.

Similar experiments upon serpentines A and B at the temperature 498°–527° gave similar results.

	A	B
Hours heated	18	18
MgO removed	10·83	14·28
R_2O_3 removed	·10	·16

In duplicate determinations at the same temperature, A yielded 14·17 and B gave 17·36 per cent of magnesia converted into chloride.

Now these data, although not satisfactorily concordant, have nevertheless some significance. They show first that the action of the gas is much the same at both of the temperature intervals, except that the limit of change is reached more quickly in the hotter series. They show, also, that the magnesia of serpentine is probably combined in two ways; one part being affected, the other unattacked by the acid. That part which is converted into chloride, and so rendered soluble, we may regard provisionally as represented by the group —Mg—OH; even though our estimate of its amount may not be so sharply accurate as might be desirable. No other hypothesis as to the nature of the dissolved magnesia seems to be practicable, or to account in any way for the results of the experiments. Roughly speaking, a maximum amount of *about* one-third of the magnesia in serpentine is extracted by dry HCl under the conditions of our experiments, the other two-thirds being more stable.

By aqueous hydrochloric acid all of the five serpentines were easily and completely decomposed. In three instances this fact was determined quantitatively; by evaporating the acid to dryness with the mineral, extracting with weak acid, and weighing the residue. In each case this residue agreed in percentage with the silica found by actual analysis. The data are as follows:

	A	C	D
Insoluble in HCl	42·32	42·21	42·55
Silica found	42·05	42·42	42·94

By very weak hydrochloric acid, however, these three serpentines are but partially decomposed; the picrolite being the most stable of the series. A microscopic examination of the picrolite by Mr. Waldemar Lindgren showed no inclusions which could account for this difference in behavior, and it is probably due to merely mechanical conditions.

Upon boiling directly with sodium carbonate solution, none of the serpentines were attacked. By sharp ignition, however, a little silica was sometimes liberated; which, as in the case of the talc, could be dissolved out and estimated. The quantities of silica thus set free were as follows:

	A	B	C	D	E
Per cent	6·23	2·00	2·98	none	6·05
	6·34	2·63			4·93

These results cannot easily be interpreted. At most, only about one seventh of the total silica is thus taken out; and this may represent either impurities in the minerals or secondary reactions of an undetermined kind.

When serpentine is heated to the point of fusion it is split up, as Daubrée has shown,* into a mixture of olivine and enstatite.

$$H_4Mg_3Si_2O_9 = 2H_2O + Mg_2SiO_4 + MgSiO_3.$$

Upon ordinary ignition, however, this breaking up of the molecule does not always take place; and when it does occur, it is as a rule only partial. In three experiments the serpentines A, C, and D, were strongly ignited over a blast lamp for an hour each, and then treated with strong hydrochloric acid. By this treatment, olivine, if formed, should be decomposed; while enstatite would remain unattacked in the residue. After evaporation to dryness and extraction with weak acid, the insoluble material was boiled with sodium carbonate solution to remove free silica, washed, dried, and weighed. The residues were as follows:

	A	C	D
Per cent	4·32	20·80	39·96

The residue from the massive Montville serpentine contained 43·28, and that from the chrysotile 41·34 per cent of magnesia, thus agreeing nearly with enstatite in composition. The picrolite residue was composed of—

MgO	36·31
SiO_2	54·88
R_2O_3	9·26
	100·45

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* Compt. Rend., lxii, 661, 1866.

wing it to be an impure enstatite, the impurities being analous to those of the original mineral. In the last case the itting up seems to have been practically complete; in the ysotile it went fully half way, while in the ordinary serpene it barely began. The conclusion is obvious. When serntine is simply dehydrated, the molecule $Mg_3Si_2O_7$, decomsable by acids, remains; and this on further heating splits in accordance with Duabrée's observations. The salt $g_3Si_2O_7$ corresponds to certain well-known silicic ethers, and robably a definite compound.

Now, bearing upon the constitution of serpentine, we have eral lines of evidence. First, its empirical formula, $Mg_3Si_2O_9$ is well-known, and in this all the water is conutional. Second, upon dehydration it yields the salt $g_3Si_2O_7$. Third, a part of the magnesia is less stably comed than the remainder of the base, and is presumably prest as —Mg—OH. If one atom of magnesium, or one-third the total, is thus combined, the excess of one atom of ygen over the normal orthosilicate ratio in the formula is ounted for, and the conditions imposed by our experimental ults are satisfied.

Taking all these considerations into view it seems highly bable that the constitutional formula of serpentine may be itten $Mg_2(SiO_4)_2H_3(MgOH)$. In ultimate structural form s may be interpreted in several ways, any one of which will mit of a linking together of the two orthosilicic groups, er dehydration, with elimination of one oxygen atom, to m the acid group Si_2O_7. Between the several possible uctures, however, we are not as yet prepared to decide, and rther investigation covering other hydro-magnesia silicates is cessary. Bearing in mind the very common derivation of pentine from olivine, and the obvious relations of both ecies to chondrodite, the following formulæ are highly sugstive; the first one representing olivine with double its nplest expression:

$Mg_4Si_2O_8$	Olivine.
$Mg_3Si_2O_8(MgF)_2$	Chondrodite.
$Mg_2Si_2O_8H_3(MgOH)$	Serpentine.

the chondrodite formula of course, the group –Mg–O–Mg– a certain extent replaces the two univalent MgF groups. though these formulæ are not absolutely proven, they are least highly probable; and they conform perfectly to the neral working hypothesis that the more complex silicates substitution derivatives of normal salts.

One other formula for serpentine, $MgSi_2O_7(MgOH)_2H_2$, is reconcilable in part with our data. But such a compound ought to be acted upon more strongly by gaseous hydrochloric acid, and two-thirds of the magnesia should be removable. This limit was not even remotely approached in our experiments, although in two cases the one-third limit was definitely exceeded. It is a legitimate question, however, whether there may not be two isomeric serpentine molecules, corresponding to these two formulæ; and this question ought to be kept in view in future investigations.

[To be continued.]

ART. XLII.—*On five new American Meteorites*; by GEORGE F. KUNZ.

1. *On the group of Meteorites recently discovered in Brenham Township, Kiowa County, Kansas.*

ABOUT four years ago, the farmers of Brenham Township ploughed up a number of heavy objects, which they used to weight down haystacks and for other like purposes, as they would have used boulders. It was discovered in March last that these were not common "rocks," but an interesting group of meteorites, numbering over twenty in all, weighing together about 2,000 pounds, and individually from 466 pounds down to one ounce. They were found imbedded at a slight depth in the soil, which here, for about one hundred feet deep is formed of Pleistocene marl, originally the bottom of an ancient lake; they occurred scattered over a surface more than a mile in length, principally, however, in a square of about sixty acres.

What is now Kiowa County, Kansas, five years ago formed parts of Edwards and Comanche counties, and was occupied by large ranges and cattle ranches. Brenham Township, or Township 27, as it was then called, is in the northwestern part of Kiowa County, consists of high prairie with some areas of sand-hills, and has an altitude of about 220 feet above sea-level. Some drains of the head-waters of the Medicine River and its tributaries, farther south, become ravines and valleys; and there a gravel occurs, the debris of Miocene "Loup Fork" conglomerates. But on the high prairie not a stone of any kind is to be found; hence the ranchmen and settlers were greatly surprised at finding heavy "rocks" or stones projecting through the prairie sod.

Several years ago, Mr. Davis, a lawyer at Greensburg, identified these as meteorites; and although the farmers had thus known the fact for a long time, yet, strange to say, no importance was attached to them until Mrs. Kimberly applied to Professor F. W. Cragin, of Washburn University, in the early part of last spring. It was not until the 13th of March that Professor Cragin secured four of these masses. They were nearly all found by being struck by mowing-machines, ploughshares, corn-cultivators, or other farm implements. Over twenty distinct masses have been reported; but it is very evident, from the weight and other facts, that some have been noted several times over. The townships are reckoned from the base-line, the 40th parallel; and the ranges, from the 6th principal meridian, which crosses Kansas about longitude 97° 30′ west of Greenwich. Brenham Township [27] is made up of thirty-six sections, each one mile square, numbering from No. 1 to No. 36. The meteorites seem to have covered an area over one mile in length. Some of them fell on the east half of the northwest quarter, Section 27, Township 28, Range 17, west of the 6th principal meridian.

The history of some of the pieces is remarkable. The 35·72-pound piece, found on the Evans place, was lost, and again found in a hole made by hogs under a barbed-wire fence. The 75-pound mass was used by Mrs. Kimberly to hold down a cellar door or the cover to a rain-barrel. Mass No. 3 was used to keep down a stable-roof. The 466-pound mass [called by the farmers the "moon meteorite"] was covered by only three inches of soil, and broke a ploughshare when first struck. Apparently none of the masses were buried to a greater depth than five or six inches.

The 101·5-pound, the 71·5 pound, and the 55-pound masses were found four years ago by a cow-boy, when the ranch had not yet been occupied by settlers, being simply used as a cattle-range. He was unable to move them to the "Green's Stage Station," now Greensburg, eight miles distant, and so buried them in the gulch a mile northwest of the Kimberly farm on the "Francisco Claim." About a year afterward he became ill, and died; but before his death he communicated the burial of the "three strange rocks," as he called them, to two of the settlers, who succeeded in finding them and bringing them to the new town of Greensburg about a year later. The 55-pound mass was carried over by a neighbor, who used it to weight down his haystack.

Professor Snow, of Lawrence, Kansas, visited Kiowa County several times, and the last time obtained the 101·5-pound mass in the streets of Greensburg, the county seat, where it had lain for several years in front of a lawyer's real estate office.

The exterior of all the masses shows the characteristic pitting. The surfaces have all been more or less oxidized by exposure to the elements, showing that the fall is not recent, and that the original mass was made of crystalline iron as well as of iron filled with crystals of olivine; in other words, the masses show two distinct groups. Of these, the 345-pound and the 75-pound ones are nickeliferous iron of highly octahedral structure and cleavage, and are caillites, while the others are meteoric iron containing olivine, and belong to the group known as pallasites.

The largest mass, a pallasite, weighs 466 pounds, or 211·818 kilos. It is thick, slightly flattened, triangular in form, somewhat heart-shaped, and measures through the longest part 61 centimeters, or 24⅛ inches; across the widest part 48 centimeters, or 19 inches; and in the thickest part, 37 centimeters, or 14½ inches. It is covered with large indentations measuring 10x6x3 centimeters. The coating is more or less oxidized, but the olivine is perceptible in all parts of the mass. The dimensions of the 345 pound mass [158·818 kilos] are 60x37x29 centimeters, or 23¾x14½x11½ inches. It is slightly arch-shaped, is an iron with many pittings, and shows the characteristic magnetic oxide of iron crust. The 219-pound mass [99·535 kilos] measures 51x41x26 centimeters [20½x16½x10½ inches; in form like a three-sided pyramid. The 211-pound mass [95·909 kilos] is somewhat rounded, with a circular depression on one side.

There are two masses weighing 125 pounds [58·863 kilos] and 54·96 pounds [25·084 kilos] respectively. The 101·5-pound mass [46·136 kilos] is almost round, measuring 35x26x27 centimeters [13¾x10¼x10¾ inches]. The exterior is evenly pitted. and the center of each pitting is occupied by an olivine crystal. The 75-pound one [34·09 kilos] is an iron, and measures 32x22½x15 centimetres [12½x8½x5⅞ inches], in shape like a pear or ham covered with pittings. The crust has been changed somewhat by weathering. The 71·5 pound mass [32·485 kilos] measures 27x23x22 centimeters [10½x9x8⅝ inches]. It is a jagged, irregular square, and shows olivine crystals all over the exterior. The 60-pound mass [27·272 kilos] measures 36x21x17 centimeters [14⅛x8x6⅝ inches]. It is an elongated, rounded piece, with one large flat side showing large spaces filled with olivine. The 40-pound [18·181 kilos] measures 22x21x13 centimeters [8⅝x8¼x5⅛ inches], of irregular shape, with one large projecting point. The 36-pound mass [16·363 kilos] measures 22x22x16 centimeters [8½x8½x6¼ inches. It is a flattened spheroid, containing some olivine, but almost entirely iron, showing large pittings like the 75-pound or the 345-pound masses.

There are seventeen or eighteen small masses weighing 18, 12, 7, 6, 5, 3 and 1 pounds respectively, and a few weighing only one ounce each. The 211 and 6 pound masses belong to the University of Minnesota; the 125-pound mass, to Harvard University; the 101·5 to Yale University; the 218½ and the 54·96-pound masses, to the University of Kansas; the others are in the collection of the writer.

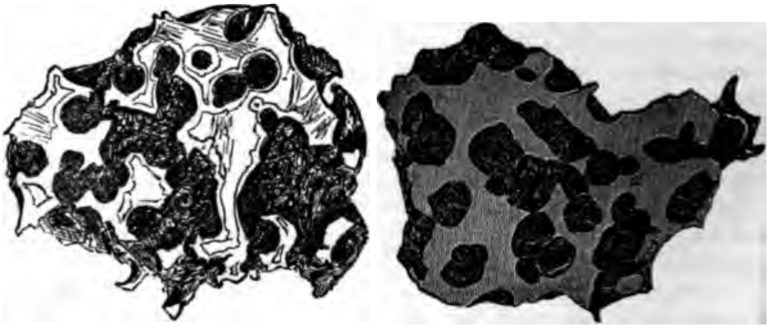
The specific gravity of the pieces is very variable, and was found to be as follows:—of the 6-pound mass, 5·17; 40-pound mass, 6·41; 71·5-pound mass, 5·22; 75-pound mass, 7·27; 345-pound mass, about the same density as the last; 466-pound mass, about the same density as the 71·5-pound mass. The following analyses of the Kiowa meteorites were made by Mr. L. G. Eakins in the laboratory of the United States Geological Survey:

Iron.		Olivine.		Dark Outer Zone of Olivine.	
Fe	88·49	SiO_2	40·70	SiO_2	34·14
Ni	10·35	Al_2O_3	tr	FeO	23·20
Co	·57	Fe_2O_3	·18	NiO	tr
Cu	·03	FeO	10.79	CoO	·03
P	·14	NiO	·02	MnO	·09
S	·08	MnO	·14	MgO	40·19
C	tr	MgO	48·02	S	5·42
Si	tr				
			99·85		103·07
	99·66			Less O for S	2·71
					100·36

The specific gravity of the iron freed from olivine was found to be 7·93 at 23·4° Celsius; of the olivine, 3·376 at 23·2°. The iron is brilliant white, enclosing the troilite, and surrounding the olivine crystals. Occasionally small etched surfaces show delicate figures like that of the Linnville Mountain meteorite. Troilite exists plentifully, in rounded grains from one to five millimeters in diameter, and in thin folia mixed with and surrounding the olivine crystals, as well as running into and filling small spaces in the body of the iron, either as flat plates or rounded masses. Several flat circular plates [crystals?] of graphite, two millimeters in diameter, were observed.

The olivine crystals are very brilliant, and break out entire, the faces on many of them being distinct enough to allow of measurement of the angles. The spaces from which they break are highly polished, showing every crystal face with a mirror-like luster; and in the center there is a coating of a shining mineral that is jet-black in color, and crushes into a jet-black powder. Many of the olivine crystals are in two distinct zones,—the inner half a bright transparent yellow, the outer a dark-brown iron-olivine. In reality this dark zone is an intimate mixture of troilite and olivine, as the analysis of

Mr. Eakins and a microscopical examination of the crystals by Mr. J. S. Diller, of the United States Geological Survey, fully prove.



This group of meteorites, which has recently come to me for description, possesses more than ordinary interest, on account both of the peculiar composition and structure and also of the undoubted ethnological relation, especially because of its probable connection with the meteoric iron found in the Turner mounds.

In the spring of 1883, Professor F. W. Putnam found on the altar of mound No. 3 of the Turner group of mounds, in the Little Miami Valley, Ohio, several ear-ornaments made of iron, and several others overlaid with iron. With these were also found a number of separate pieces that were thought to be iron. They were covered with cinders, charcoal, pearls [two bushels were found in this group of mounds], and other material, cemented by an oxide of iron, showing that the whole had been subjected to a high temperature. On removing the scale, Dr. Kennicutt found that they were made of iron of meteoric origin.* One of the pieces weighed 28 and the other 52 grains.

In the autumn of 1883, a mass was found on the altar of mound No. 4 of this same group, which weighed 767·5 grams [27·25 ounces]. Dr. Kennicutt suggested that these were all parts of some larger meteoric mass. The results of the investigation were published in connection with the description of the Atacama meteorites, because in structure they approach more closely to the latter than to those of any other occurrence known at that time. In the Liberty group of mounds in the same valley, Professor Putnam found a celt five inches long, and in another of the Turner mounds an ornament five inches long and three inches wide, made also of the same meteoric iron.

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* Sixteenth and seventeenth reports of the Peabody Museum of Archæology, p. 382.

The Carroll County meteorite was found in 1880, about ree-quarters of a mile from Eagle Station, Carroll County, entucky, ten miles from the mouth of the Kentucky River, nd about seven miles in a direct line from both the Kentucky nd the Ohio Rivers. The distance to the Turner mounds, here Professor Putnam found the meteoric iron and the rnaments made of it, is about sixty miles. The mass, which eighed about eighty pounds, or 36·5 kilos, was rusted on the rface to a depth, in some places, of 10 to 12 millimeters; nd deep pits, some two centimeters across, are observed in the pots where grains of olivine have probably dropped out. he meteorite was largely made up of fine yellow transparent livine resembling that of the famous Pallas iron, with a pecific gravity of 4·72.

Taking the specific gravity of the iron at 7 6, and that of he olivine at 3·3, we find that the Turner mound meteorites onsist of about three parts of olivine to one of iron. Several f the Kiowa masses have about the same constitution. For omparison, see the analyses of the Kiowa meteorites, given bove, and of the olivine and iron from the Turner mound,* here inserted, as follows:

Olivine.		Iron.	
SiO_2	40·02	Fe	89·00
FeO	14.06	Ni	10·65
MnO	0·10	Co	0·45
MgO	45·60	Cu	tr
	99·78		100·10

When the Carroll County iron was described by the author n this Journal (vol. xxxiii, March, 1887), it was suggested hat the pieces found by Professor Putnam in the Miami mounds had probably been taken from that mass, since no other olivine meteorite had up to that time been found in North America; while that of Carroll County contained a large percentage of olivine, even greater than the mound specimens. Very little cutting had been done on the Carroll County mass; and it proved on being cut, not to be a pallasite, but a brahinite variety of meteorite. In the Little Miami valley meteorite are embedded circular grains or crystals of olivine; whereas that of the Carroll County consists of a mass of olivine in which the iron serves as a filling between the crystals. When a section was cut from the Kiowa County material, however, there appeared no doubt as to the identity of this fall with that from which the ear-rings were made that were found in the mound. In both the Kiowa County and the mound specimens the body of the meteorite is iron in which are imbedded circular masses or crystals of olivine. The fact that in connection with the large Kiowa masses a number of small portions, weighing from half a pound to six pounds each, were found, makes it very probable that a small mass, of perhaps three or four pounds, had been conveyed by the Indians to the Ohio valley. Probably the two ear-rings in the collection of Mr. Warren K. Moorhead, recently found by him at Fort Ancient, Ohio, may have been made from a part of the mass weighing 767·5 grams, which is now in the Harvard University collection.

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* Kennicutt; 16th and 17th Reports of the Peabody Museum of Archæology, p. 382.

I must here express my indebtedness to Professor F. H. Snow for information, and particularly to Professor Robert Hay for aiding me in procuring many of the meteorites and assisting greatly to obtain exact data by visiting the place of discovery, and to secure the illustrations; as also to Mr. L. G. Eakins for making the analyses, and to Professor F. W. Clarke, of the U. S. Geological Survey, for his courtesy in having them made at the Survey Laboratory.

2. *On the Winnebago County, Iowa, Meteorite.*[*]

On Friday, May 2, 1890, at 5.15 P. M., standard Western time, a meteor was observed over a good part of the State of Iowa. It is described as a bright ball of fire, moving from west to east, leaving a trail of smoke which was visible for from ten to fifteen minutes; it was accompanied by a noise, likened to that of heavy cannonading or of thunder, and many people rushed to their doors, thinking it was the rumbling of an earthquake. Substantiated reports have been received from DesMoines, Mason City, Fort Dodge, Emmetsburg, Algonia, Ruthven, Humboldt, Britt, Garnet, Grinnell, Sioux City and Forest City; the noise was also heard at Chamberlain, South Dakota. Some of these places were distant more than a hundred miles from the point where the meteor fell. It exploded about eleven miles northwest of Forest City, at Leland, Winnebago County, in the center of the northern part of Iowa, latitude 43° 15′, longitude 93° 45′ west of Greenwich, near the Minnesota State line, and the fragments were scattered over an area one mile wide and nearly two miles long. Up to the present time, there have been found masses weighing respectively eighty pounds, sixty-six pounds and ten pounds, two of four pounds and about five hundred fragments weighing from one-twentieth of an ounce to twenty ounces each, while a part of the mass is believed to have passed over into Minnesota. The pieces are all angular, with rounded edges.

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[*] Read before the New York Academy of Sciences, May 12, 1890.

The meteorite is a typical chondrite, apparently of the type of the Parnallite group of Meunier, which fell February 28, 1857, at Parnallee, India. The stone is porous, and when it is placed in water to ascertain its specific gravity, there is a considerable ebullition of air. The specific gravity, on a fifteen-gram piece, was found to be 3·638. The crust is rather thin, opaque black, not shining, and, under the microscope, is very scorious, resembling the Knyahinya, Hungary, and the West Liberty, Iowa, meteoric stones. A broken surface shows the interior color to be gray, spotted with brown, black and white, containing small specks of meteoric iron, from one to two millimeters across. Troilite is also present in small rounded masses of about the same size. On one broken surface was a very thin scum of black substance, evidently graphite, soft enough to mark white paper; a feldspar (anorthite) was likewise observed, and enstatite was also present.

Results and analyses furnished by L. G. Eakins.

Approximate composition of the mass.		Analysis of the Nickeliferous Iron.	
Nickeliferous iron	19·40	Fe	92·65
Troilite	6·19	Ni	6·11
Silicates soluble in HCl	36·04	Co	·65
Silicates insoluble in HCl	38·37	P	tr
			99·41

Specific gravity of the mass, 3·804 at 28·5° Celsius.

Analysis of the siliceous portion, with the magnetic extracted.

Soluble in HCl.			Calc. to 100 p. c.		Insoluble in HCl.		Calc. to 100 p. c.
	(1.)		(2.)	(3.)		(4.)	(5.)
SiO_2	17·82		17·82	39·74	SiO_2	26·49	55·51
					Al_2O_3	2·59	5·43
FeO	14·27	6·01 FeO, equiv. to 4·67 Fe, required by S to form FeS	8·26	18·42	Cr_2O_3	·12	·25
					FeO	4·49	9·45
NiO	·17		·17	·38	NiO	tr	
MnO	tr		tr		CaO	1·45	3·00
CaO	·31		·31	·69	MgO	11·50	24.09
MgO	18·28		18·28	40·77	K_2O	·07	·15
Alkalies	tr		tr		Na_2O	1·01	2.12
S	2·67	[2·678 to form FeS]					
P_2O_5	tr		tr			47·72	100·00
	53·52		44·84	100·00			
O for S	1·34						
	52·18						

The approximate composition of the mass was got by extracting everything possible by an electro-magnet, which took out all the nickel iron and a little troilite, leaving the siliceous part and most of the troilite. Then the amount of S present in the magnetic portion, and that in the siliceous portion, was calculated as FeS; the silicates were split into two portions by

HCl, and by the weights found in each case, the given approximate composition was calculated. Under the head of analysis of nickeliferous iron is given the analysis of the metallic portion after allowing for a very slight amount of attached silicates and troilite.

The analyses numbered from 1 to 5 are the residue left after removing all the magnetic material. Column 1 is the part soluble in HCl, column 4 that insoluble in HCl; these two added together would give the analysis as a whole of the non-magnetic portion. Column 2 is the same analysis as 1, after removing the 2·67 per cent S and an amount [6·01 per cent] of FeO equivalent to the Fe necessary to form troilite with the S. Column 3 is the same as 2 calculated to 100 per [illegible] Column 4, as stated, is the analysis of the insoluble po[illegible] and 5 is the same to 100 per cent. It is of course prob[illegible] that the Cr_2O_3 represents chromite, and possible that the alkalies and alumina with a little lime represent a soda-lime feldspar.

The thanks of the author are due to Mr. L. G. Eakins for the analysis and results furnished, and to Professor F. W. Clarke for his courtesy and assistance by having the analyses made in the U. S. Geological Survey Laboratory.

3. *On the Meteoric Stone from Ferguson, Haywood County, North Carolina.*

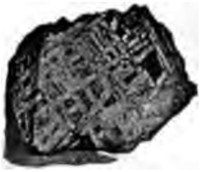
Mr. W. A. Harrison, of Ferguson, Haywood County, North Carolina, says: that about six o'clock on the evening of July 18, 1889, he noticed a remarkable noise west of him, and that fifteen minutes later he saw something strike the earth, which, on examination, proved to be a meteoric stone, so hot that he could scarcely hold it in his hand five minutes after it fell. Two-thirds of its bulk was buried in the earth when found. This stone was sent to the writer and was unfortunately lost in New York city during the month of December. The stone was slightly oblong, covered with a deep, black crust, which had been broken at one end, showing a great chondritic structure with occasional specks of iron. Its weight was about eight ounces: and it very closely resembled the meteoric stone from Mocs, Transylvania. It remained in the writer's possession so short a time that it was not properly investigated, but still the mere mention of a fall which had been so carefully observed is thought to be well worthy of publication.

4. *Meteoric Iron from Bridgewater, Burke County, North Carolina.*

The Bridgewater, Burke County, meteorite was found by a negro plowman, two miles from Bridgewater Station, in the

part of Burke County, near the McDowell County
North Carolina, latitude 35° 41′, longitude 81° 45′
Greenwich. The negro thought that it must be either
silver, from its weight, and took it to some railroad
, who broke it in two pieces, one of which weighs
a half pounds, and the other eighteen and a half pounds,
· 30 pounds, equal to 13·63 kilos. It measures 22½x15
[9x6x4 inches.] [See fig. 1].

s of black crust very much oxidized are still visible on
ace. The iron is highly octahedral in structure, and
s was readily broken by the laborers who found it.
n the cleavage plates schreibersite is visible. On etch-
lished surface of this iron with dilute nitric acid, the
ristic Widmanstätten figures were
(see fig. 2). The iron belongs to the
group and resembles those of the
Creek and Glorietta Mountain in
e. The specific gravity of a frag-
as found to be 6·617. The following
was kindly furnished by Professor
enable of the University of North Carolina.



Fe	88·90
Ni	9·94
Co	·76
P	·35
Cl	·02
	99·97

The nickel is the mean of two determinations, 9·74 and 10·14, on different parts of the sample; the cobalt also of two determinations, ·85 and ·67. The iron is the mean of four determinations, some of which were not very closely agreeing, as the crust could not be entirely removed from the samples taken. The phosphorus and chlorine are single determinations. The author takes great pleasure in thanking Mr. T. K. Brunner for his courtesy in obtaining the information and the iron for him, and also Professor F. P. Venable for furnishing the analysis.

5. *Meteoric Iron from Summit, Blount County, Alabama.*[*]

This mass of meteoric iron was found near Summit, Blount County, Alabama, latitude 33° 41′, longitude 86° 25′ west of Greenwich, in Fraction A, Section 2, Township 10, Range 1, east, by a six-year-old negro girl who used it to crack hickory nuts. Its great weight excited some curiosity, and her brother sent it to Mr. St. John, of Summit, and through the courtesy of Professor Eugene A. Smith it passed into the possession of the writer. It measures 12·5x5x7·5 centimeters [5x2x3 inches] and weighs one kilogram [2 2 pounds].

This meteorite contains a large quantity of free chloride of iron [Lawrencite] which from time to time has formed in beads on the surface. It showed only a slight trace of the original crust and was almost completely oxidized; and on etching a polished surface of this iron with nitric acid no Widmanstätten figures were developed, but instead a fine marking similar to that of the Linnville Mountain, N. C., meteorite The specific gravity of a fragment was 6·949. The following analysis was kindly given by Professor F. P. Venable of the University of North Carolina:

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[*] Trans. N. Y. Acad. Sciences, Jan. 27, 1890.

Fe	93·39
Ni	5·62
Co	·58
P	·31
	99·90

The iron is the mean of three fairly agreeing determinations, e nickel of two determinations, 5·61 and 5·63, the cobalt of ro determinations, and the phosphorus is a single determina- on.

We take great pleasure in thanking Professor Eugene A. nith for his assistance in obtaining the iron, and Professor F. . Venable for furnishing the analysis.

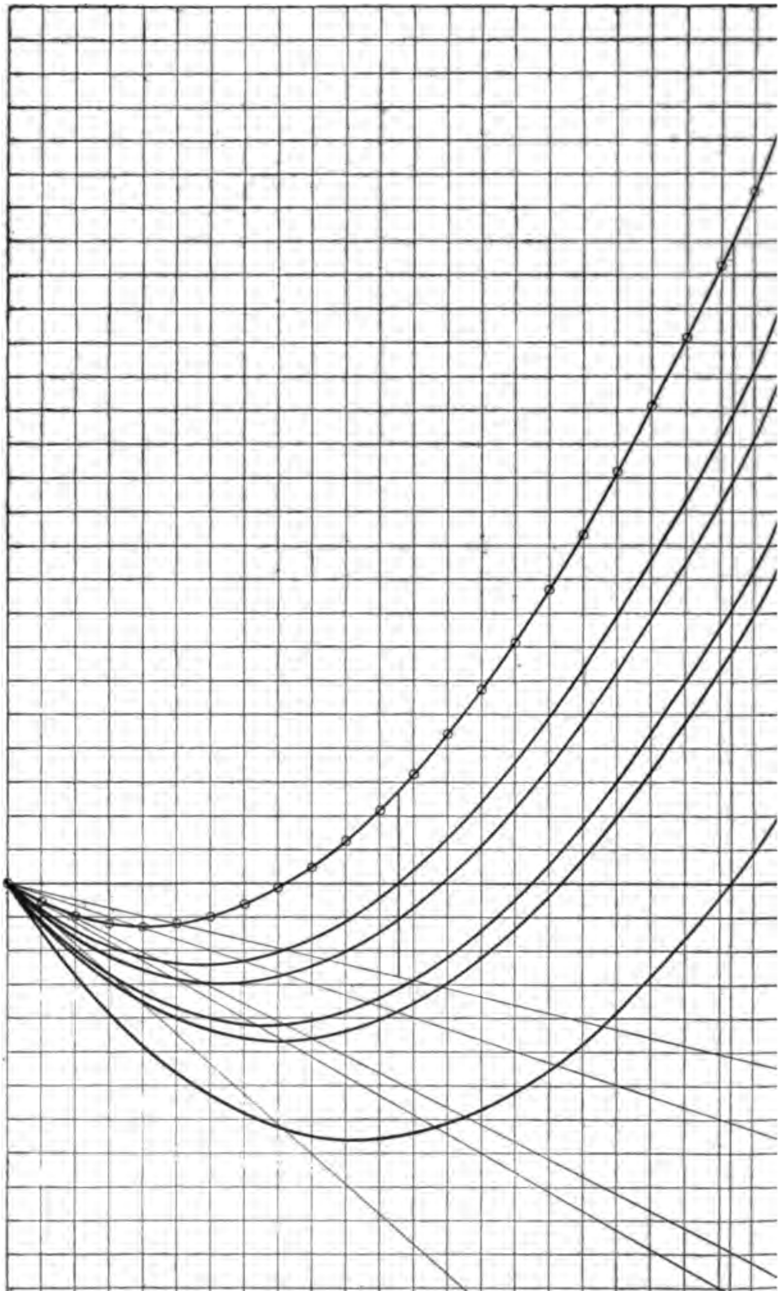
RT. XLIII.—*On the determination of the coefficient of cubical expansion of a solid from the observation of the temperature at which water, in a vessel made of this solid, has the same apparent volume as it has at 0° C.; and on the coefficient of cubical expansion of a substance determined by means of a hydrometer made of this substance;* by ALFRED M. MAYER.

ead before the National Academy of Sciences, at Washington, April 21, 1886.]

The curve W of Fig. 1 shows the absolute expansion of ater. The unit of abscissæ of this and the other curves is ' C., the unit of ordinates is $\frac{1}{10000}$ of the unit of volume of e water, this unit of volume being at 0° C. The curve shows the apparent expansion of water in a glass vessel, and irves S, C, B and Z are the respective curves of the apparent pansion of water in steel, copper, brass and zinc vessels. he curve W cuts the axis of X at 8°4 centigrade; G at °·7; S at 12°·8; C at 15°·3; B at 16°·3; Z at 21°·5. These oints of intersection correspond to the following coefficients ' cubical expansion; for G, ·000025; for S, ·000033; for C, 0005; for B, ·000056; for Z, ·00009.

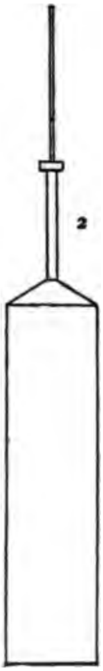
Let us consider the curve G. The curve goes below W be- use water contracts from 0° to 4°, and the glass vessel by panding adds to this fall of the water. Beyond 4° the water pands more than the glass and at 11°·7 the expansion of e water from 0° to 11°·7 equals the expansion of the glass rough the same range of temperature, and the curve G cuts e axis of X at 11°·7. Therefore, to obtain the cubical pansion of the glass, or of any other substance forming the essel, we have merely to determine the temperature at which ater has the same apparent volume that it has at 0° C., and

1.



t this temperature on the axis of X we measure the ordinate f the curve of the absolute expansion of water, and this rdinate gives in volume the expansion of the vessel in the letermined range of temperature.

The second method of determining the coefficient of cubical xpansion is that of floating a hydrometer, formed of the subtance whose coefficient we would determine, in water at 0° C. nd then gradually heating the water till the hydrometer floats to the same depth it did when the water was at 0° C′. Calling W the weight of the hydrometer, and V_0, D_0, V_t and D_t the respective volumes and densities of the water at 0° and t°, we have $V_0D_0=W$, and $V_tD_t=W$, and if V_0 and D_0 equal unity we have $V_t=1/D_t$, or, the volume at t° is the reciprocal of the density at t°, which is the same as if we took V_t directly from the curve of the absolute expansion of water. Thus, by having the true curve of the absolute expansion of water, one may determine by either of the two methods just decribed, the coefficient of cubical expansion of a solid without measures of volume, of weight or of linear dimension.



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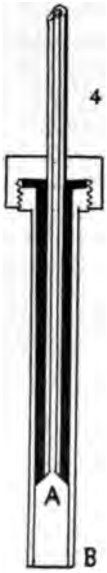

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We will now describe the apparatus used, give some measurements made with it nd discuss the accuracy of the methods. Fig. 2 is the brass vessel used. It is a cylinder 25·4 cms. long and 6·147 cms. interior diameter. A glass tube ·203 cm. diameter of bore is connected with the interior of the cylinder as shown in Fig. 4. Into a brass tube shown black in the figure is cemented the glass tube. The lower opening of these tubes, A, is ground into a cone. The houlder of this tube A rests on a thin leather washer on the top of the tube B. A screwcap forces the tube A into close contact with B. This manner of attaching the glass tube to the cylinder was devised for convenience in our experiments, but the glass tubes may be directly cemented into the cylinder and thus do away with the inner tube and screwcap.

The cylinder is nearly filled with distilled water and a rubber tube is led from the tube of the cylinder into a vessel holding boiling water. The water in the cylinder is boiled for a half hour and then the heat is withdrawn. As the steam condenses the vessel fills with water. The apparatus is allowed to cool down to the temperature of the room. The cylinder and glass tube is now surrounded with ice, and when the level of the water in the tube has remained stationary for 15 minutes it is marked by pasting on the tube a piece of thin tracing paper on which is drawn in ink a very fine line. This line is made tangent to the meniscus of the water by the aid of a cathetometer. The ice is now replaced by cold water which is slowly heated. When the temperature had reached 8° C. the volume of water (in this special apparatus) had fallen 11 cms. below the level it had at 0°. It then slowly rose till at 15°·9 C. it reached the level it had at 0°. The temperature of the air of the room was above 15° 9. When the water was raised to 12° it was allowed, under constant agitation, slowly to reach 15°·9. To be sure that this was the temperature of the water inside the vessel the water outside was kept at this temperature by adding from time to time small portions of cold water. The water level remained the same for 10 minutes.

Referring to a curve of absolute expansion of water (drawn to the scale of 1 mm. = $\frac{1}{1000000}$ of unit of volume) we find that the ordinate of 15°·9 is 1·000853, which is the cubical expansion of the brass caused by heating it from 0° to 15°·9, and ·000853 divided by 15°·9 gives ·00005364 the coefficient of cubical expansion of brass of the following composition: copper, 78·5 per cent; zinc, 21·05; lead, 0·25; tin, 0·15.

The delicacy of the method depends on the relative dimensions of the vessel and tube. In the apparatus just described the interior diameter of the vessel is 6·147 cms; its length 25·4 cms; the bore of the tube is ·203 in diameter; hence $\left(\frac{6{\cdot}147^2}{{\cdot}203^2} \times 25{\cdot}4\right) \div 1000 = 23{\cdot}589$, the length in cms. that the level of the water changes for a change of $\frac{1}{1000}$ in the volume of the cylinder, and a change of $\frac{1}{1000000}$ of the volume equals ·023 cm., or ·23 mm., of motion of water in the tube. From the curves of apparent expansion of water in vessels of the following named materials we find that a change of 0°·10 in the water at the temperature when the water has the same apparent volume as at 0° equals a change of volume given opposite the respective materials forming the vessels as follows:

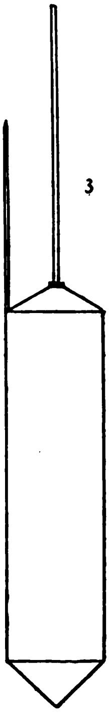
± 0°·1 C. causes	a change of	apparent volumes of	·000008	in a	glass	vessel.
"	"	"	·000009	"	steel	"
"	"	"	·000010	"	copper	"
"	"	"	·000011	"	brass	"
"	"	"	·000013	"	zinc	"

From above data we compute that with a cylinder, or bulb, and tube of the same dimensions as those of the brass vessel and tube described,

± 0°·1 C. causes	a motion of	1·84 mm.	in a similar vessel of	glass.
"	"	2·07 "	"	steel.
"	"	2·30 "	"	copper.
"	"	2·53 "	"	brass
"	"	2·99 "	"	zinc.

The cathetometer readily detects and measures a motion of $\frac{1}{10}$ mm.; so it appears that a change of temperature of $\frac{1}{400}$° causes a change in level of water in the tube which can observed. The thermometer, however, was read only to $\frac{1}{20}$°.

It remains to examine into the effect of the glass tube attached to the metallic vessel. This tube is necessary in order to observe the level of the water, but to get a rigorously correct observation the vessel and tube should be of the same substance. The effect of replacing the glass tube by a similar one of the same material as that of the vessel is readily calculated and is found to be a quantity that may be neglected. Thus in a brass tube 50 mm. long and 2·03 mm. in diameter the level of the water at the higher temperature of 16° will stand ·014 mm. lower than in a glass tube of the same dimensions, and at 21°·5 the water will be ·05 mm. lower in a zinc tube than in one of glass.



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The coefficient of cubical expansion of glass was determined by means of a spherical vessel of 12 cm. diameter with a tube of 2·5 mm. interior diameter. The level of the water in this vessel was the same at 11°·75 and at 0°. The volume of water at 11°·75 is 1·0003 and $\frac{\cdot 0003}{11\cdot 75}$ = ·0000255 the coefficient of cubical expansion of this kind of glass. Kopp gives ·000024 and ·000026 as the coefficients for a similar soda glass.

The coefficient of expansion hydrometer was used to determine the coefficients of expansion of brass and of hard rubber, or ebonite. The hydrometer, fig. 3, was made of the same kind of brass as that forming the cylinder used in the determination of this coefficient. The cylinder of the hydrometer is 25·5 cm. long terminated by cones. Its diameter is 7·3 cm. The stem of the hydrometer is a brass tube of 2 mm. exterior diameter. The hydrometer of hard rubber is a cylinder 21·5 cm. long and 6·5 cm. in diameter with a stem 2 mm. in diameter. To float these hydrometers in water at 0° and at a higher temperature, a pointed rod, as shown in the figure, was used. This point, by just touching the surface of the water, showed the depth of flotage. These hydrometers were made to float in water at 0°, with their index-points just touching the surface of the water, by loading them with fine shot. The water was then slowly heated and it was found that the brass hydrometers floated to the same depth at 0° and at 15°·85, and the hard rubber hydrometer had the same depth of flotage at 0° and at 38°·55.

The volume of water at 15°·85 equals 1·060845, and $\frac{\cdot000845}{15\cdot85}$ = ·0000533, the coefficient of cubical expansion of the brass. The previous determination with the brass cylinder gave ·0000536.

The volume of water at 38°·55 is 1·00697, and $\frac{\cdot00697}{38\cdot55}$ = ·0001808, the coefficient of expansion of hard rubber. Mercury has at 30° a coefficient of ·0001805. Hard rubber has the greatest coefficient of any solid. To show on the curve of apparent expansion of water in a vessel of hard rubber its points of intersection of the axis of x, on the scale of fig. 1, the axis of x would have to be extended $\frac{4}{10}$ of its present length.

These determinations with the hydrometer have the advantage of those made by observations on the volume of water contained in a vessel, because the metal of the hydrometer changes its temperature with that of the water, which is not the case with the vessel filled with water, whose temperature lags behind that of the outside water. This makes the observation on the upper temperature of the water in the vessel tedious and not precise unless the precautions are taken which we have already mentioned.

The accuracy of this method of determining the mean coefficient of expansion of water, in the determined range of temperature, depends on having the water in the vessel and the substance of the hydrometer at the same temperature as the water surrounding these bodies. This can be obtained to $\frac{1}{10}$° C. In the case of a vessel filled with water we have already stated the precautions necessary. The hydrometer is floated in water at 0° by surrounding with ice a vessel holding water which has already been cooled to 0° and from which the floating ice has been removed.

The accuracy, however, of this method depends essentially on having the true curve of the absolute expansion of water between 0° and 30°. It is not possible to say to what approximation we have this true curve; but that it is quite close may be inferred from the following account of how Rossetti projected a curve which is the best we have at present.

Prof. F. Rossetti describes his experiments and the manner of obtaining the curve in the Atti dell' Instituto Veneto, vol. xiii, 3 series, 1868. Rosetti's new determination of the volume of water at various temperatures between −6° and 100° were made with every precaution to ensure accuracy. He then combines the results of his experiments in a curve projected according to the method of Schiapparelli.* He then combined his results, thus reduced, with those of Depretz (1839); Kopp

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* Schiapparelli, Sul modo di ricavare la vera expressione dellé leggi della natura dalle curve empiriche; Nuovo Cimento, Tomo xxv, 1867; e Tomo xxvi. 1867.

(1847); Pierre (1845–52); Hagen (1855); and Matthiesen (1866). These six series of determinations were also combined by the method of Schiapparelli and the resultant curve Rossetti adopted as the most accurate attainable from existing data. From this curve, in which 1 mm. of ordinate equalled $\frac{1}{100000}$ of the volume of water at 0° C., he obtained the following formula which represents the curve quite closely.

$$V_t = 1 + a(t-4)^2 - b(t-4)^{2\cdot 5} + c(t-4)^3$$

when

$a = \cdot 00000837991$; $b = \cdot 000000378702$; $c = \cdot 0000000224329$.

From Rossetti's table of the relations of the volume, density and temperature of water we extract the following data which are all that will be required in their application to our method of determining the coefficient of cubical expansion.

Temp. C°.	Volume.	Temp. C°.	Volume.	Temp. C°.	Volume.
0	1·000000	14	1·000572	28	1·003553
1	·999943	15	1·000712	29	1·003835
2	·999902	16	1·000870	30	1·004123
3	·999880	17	1·001031	31	1·00442
4	·999871	18	1·001219	32	1·00473
5	·999881	19	1·001413	33	1·00505
6	·999901	20	1·001614	34	1·00538
7	·999938	21	1·001828	35	1·00572
8	·999985	22	1·002049	36	1·00608
9	1·000047	23	1·002276	37	1·00645
10	1·000124	24	1·002511	38	1·00682
11	1·000216	25	1·002759	39	1·00719
12	1·000322	26	1·003014	40	1·00757
13	1·000441	27	1·003278		

Stevens Institute of Technology, Hoboken, N. J.

SCIENTIFIC INTELLIGENCE.

I. Physics.

1. *Steam Calorimeter.*—K. Wirtz has modified the steam calorimeter of Bunsen and Jolly and has shown how the method of these investigators can be employed to measure the latent heat of vapor of substances with low boiling points. A weighed amount, G, of the substance is vaporized in the steam of the calorimeter. Heat is withdrawn from the steam and a portion of the latter is condensed. Calling w the weight of the condensed steam, λ the latent heat of steam, the latent heat, Q, of the vapor of the substance between the temperature before it is put into the calorimeter and its boiling point will be $Q = \frac{w\lambda}{G}$. The author discusses the sources of error. The results obtained by him are in general smaller than those obtained by Regnault, Person and Andrews. This failure of agreement is attributed by the author to the use of impure substances by the previous

observers. As an illustration of the effect of impurity of substance he instances ethyl ether; distilling this substance over sodium a loss of only 0·7 of one per cent resulted, whereas there was a diminution of five per cent in the value of the latent heat. —*Ann. der Physik und Chemie*, No. 7, 1870, pp. 438–449. J. T.

2. *A Mountain Magnetometer.*—O. E. MEYER has adapted the method of observation employed by Kohlrausch with the variometer to a new instrument. Both the movable needle and the controlling magnet move in a vertical plane instead of in a horizontal one. The instrument is thus a species of dipping needle or a vertical variometer. The author finds it well adapted to observing the attraction of large masses of rock, and to noting changes in the magnetic field in various parts of observatories and laboratories caused by variations in the magnetic condition of the materials of which these buildings are constructed. Observations with this new instrument show that large variations frequently observed in buildings can be attributed as much to change of direction of the magnetic force as to change in total value. The instrument is constructed by W. Siedentopf, University Mechanic in Würzburg.—*Ann. der Physik und Chemie*, No. 7, 1890, pp. 489–504. J. T.

3. *Velocity of Transmisison of Electric Disturbances.*—Maxwell's theory of light demands that the velocity of transmission of electric disturbances along a wire should be equal to the velocity of light through the dielectric surrounding the wire. The velocity is thus determined by the surrounding dielectric in which the energy resides. Professor J. J. THOMSON has made a number of experiments upon this subject and finds that the velocity of electric disturbances along wires surrounded by air is 1·7 times the velocity along the wire surrounded by sulphur. Experiments showed also that the velocities along wires surrounded by air, paraffin and sulphur are approximately proportional to the reciprocals of the square roots of their specific inductive capacities. The velocity of propagation of a rapidly alternating current along an electrolyte surrounded by air was found not to differ much from the rate along a wire. Experiments with a vacuum tube fifty feet long and a revolving mirror showed that the velocity of discharge through the rarefied gas was comparable with the velocity of light. The experiments on the rate of propagation of electric disturbances lead one to regard the conductor as merely guiding the discharge, "the correlation between the ether and the conductor compelling the discharge to travel along the latter with the velocity of light." Professor Thomson then discusses the application of his observations to the theory of electric striæ in vacuum tubes.—*Phil. Mag.*, Aug. 1890, pp. 129–140. J. T.

4. *Phosphoro-photographs of the ultra red.*—E. LOMMEL has taken up anew the method of Becquerel of observing the solar spectrum in the ultra red by means of phosphorescent substances. The spectrum is received on a surface covered with Balmain's paint. A dry photographic plate is then laid upon the phosphor-

escent image and a photograph can be taken as far as wave-length $\lambda = 950$. Photographs were taken both by the prism method and by Rowland's concave grating.—*Ann. der Physik und Chemie*, No. 8, 1890, p. 681. J. T.

5. *Photography of Oscillating Electric Sparks.*—This has been accomplished hitherto by a revolving mirror or a revolving lens which spreads out the image of the spark. Professor Boys employs six lenses placed on a brass disc, on different radii. The disc revolves at a high rate of speed. The spark is formed on one side of the disc and a photographic plate is placed upon the other side.—*Phil. Mag.*, Sept. 1870, pp. 248–260. J. T.

6. *Electrical Discharges in Magnetic Fields.*—The experiments of M. A. WITZ upon the action of magnets on electrical discharges in Geissler tubes leads him to believe that this action is due to a variation in the capacity of the tubes. They become true condensers and their illumination is the result of an oscillatory discharge of the same order as that of a Leyden Jar, of which the period T is a function of the capacity C of the jar, and of the coefficient L of self-induction of the conductor of small resistance, $T = \pi\sqrt{CL}$. A variation of the capacity C would thus modify the vibratory state of the gas and would be the cause of the differences observed in the luminous phenomena in intense magnetic fields.—*Nature*, Aug. 14, 1890, p. 384. J. T.

7. *Molecular Theory of Induced Magnetism.*—Professor EWING states in a summary to an article on this subject his conviction of the truth of the molecular theory of induced magnetism, which is Weber's theory in a modified form. Perhaps the most important conclusion drawn is this, "That magnetic hysteresis and the dissipation of energy which hysteresis involves are due to molecular instability resulting from the intermolecular magnetic actions, and are not due to anything in the nature of frictional resistance to the rotation of the molecular magnets."—*Phil. Mag.*, Sept. 1890, pp. 205–222. J. T.

8. *Note.*—Error in Maxwell, vol. ii, § 544. Corrected by a second fault so that final result is correct.—*Nature*, 35, p. 172, 1886.

9. *The Elements of Laboratory Work.* A course of natural science; by A. G. EARL, M.A., F.C.S. 177 pp. London, 1890 (Longmans, Green & Co.).—This is an introduction to work in the physical laboratory, dealing with the fundamental phenomena and laws. These are taken up in such a manner and order of sequence as to lead the student to a knowledge of the principles involved rather than the details of manipulation. Some of the chapters consider the measurement of quantity of matter, observations of change of position, of changes of temperature, of natural changes exhibited by all kinds of matter and by certain kinds of matter—the former bringing in the idea of gravitation, etc., the latter of electric and magnetic stress. Further, an investigation of various kinds of matter, observations leading to the theory of the ether, etc.

II. GEOLOGY AND MINERALOGY.

1. *Notes on the meeting of the Geological Society of America at Indianapolis.* (From a letter to one of the editors.)—The summer meeting of the Geological Society was held on Tuesday, Aug. 19, Vice-President Alexander Winchell, in the absence of Prof. Dana, taking the chair. Eight papers were read in the course of the three sessions of the day. Mr. W J McGee gave an account of the Appomatox formation in the Mississippi embayment. He admitted that the formation traced to the Mississippi, became identified with the Lagrange formation of Safford and was equivalent also with a part of the Orange sand of Hilgard. Dr. Safford, who was present, expressed his willingness to surrender the name Lagrange; but it was questioned by others whether the law of priority should not hold.

Prof. C. H. Hitchcock gave an account of the Redonda phosphate occurring on Redonda, one of the Leeward islands of the Caribbean sea—first described and analyzed by Prof. C. U. Shepard (American Journal of Science for 1869 and 1870), making it a hydrous iron-alumina phosphate. He stated that it overlies and penetrates irregularly a basic lava, and is interstratified with it. It was originally covered with a bed of guano. Prof. Hitchcock expressed the opinion that it was of igneous origin, which was contested by Mr. N. H. Winchell, who regarded a guano origin as most probable. Mr. E. W. Claypole presented a paper on "The Continents and the deep seas."

Prof. C. L. Herrick discussed "The Cuyahoga shale and the Waverly problem," distinguishing three horizons in the Waverly—the upper corresponding to the Keokuk and Burlington; the middle, to the Kinderhook; and a lower represented by the Berea. The Bedford shale was made Devonian.—N. H. Winchell presented a paper on the Taconic area of Minnesota and western New England, making out five horizons of iron ores in Minnesota—namely, in descending order, (1) The hematite and limonite of the Mesabi, represented by the Penokee-Gogebic Range, the ores originally iron-carbonate; (2) Titaniferous magnetite, associated with the great Gabbro range; (3) Siliceous magnetite, at the base of the gabbro; (4) The hematite and magnetite of the Kewatin, as at Vermilion Lake and Ely; and (5) The ores of the crystalline schists.

Prof. H. S. Williams discussed the question—What is the Carboniferous System? Mr. A. Winslow described the Geotechtonic and Physiographic geology of western Arkansas.

Mr. McGee read a paper by Lawrence C. Johnson on the Nita Crevasse on the Mississippi. It was stated that this crevasse was the most extensive that had been opened for many years. Through it an immense volume of water escaped into the lakes—a volume not yet accurately measured, but probably equal to that of the Missouri during flood, or that of the Delaware, Susquehanna, Potomac and James rivers. The effect of this vast volume of esh water was to transform the previously brackish lakes and aline bays into fresh-water lakes and estuaries. But the result, hich it was the special purpose of the communication to bring out, as the destruction of the salt-water fauna and the substitution f fresh-water and mud-loving fauna over an immense area. uring the recent year an important industry of the gulf coast bout the outlets of the lakes mentioned was oyster fishing, but he oyster beds all along the coast have been injured and in many ases destroyed. The sea-fishery region has also been ruined, and he pickerel and other characteristic fishes of the Mississippi may ow be taken where four months ago only salt-water forms were ound. This transformation in the fauna of the region is of im-ense economic importance. Valuable industries have been de-troyed; prices of standard commodities in New Orleans and ther Southern cities have been affected. Of even greater scien-ific interest is the transformation, for it illustrates a transition rom a marine to a fresh-water fauna over hundreds of square iles effected within a few weeks. Hitherto the geologist em-loyed in the lower Mississippi region has been puzzled to account r sudden transitions from fresh-water to salt-water deposits, and ice versa; but there is here a modern example of as wide extent s in all those which have hitherto embarrassed the student.

The reading of geological papers was continued before the merican Association then in session. A list of the papers is iven beyond, on pages 339, 340.

2. *Making of Icebergs.*—Mr. Henry B. Loomis, of Seattle, was t the Muir glacier for nearly seven weeks this summer, with Prof. ohn Muir. In a description of the visit (which mentions the nfortunate feature of 20 days of almost continuous rain) he gives e following account of the making of icebergs at the terminal all of the glacier.—Blocks of ice, some of them of enormous size, ll off from this wall at frequent intervals. The falling of the ergs is very irregular; at times a berg is discharged as often as very five minutes, at another time you may wait an hour with-ut seeing one fall. On one day, during twelve hours, we counted 29 thundering reports, loud enough to be heard at camp, a mile r more from the falling bergs. During some days and nights, specially during a heavy rain, we were reminded of a cannon-de or thunder-storm, and the ground beneath us seemed to trem-le. Sometimes a huge block breaks off, crumbles into a million agments, and, leaping like a catract, falls gracefully into the bay ith a long thundering noise, scattering around the white and ealy spray which glistens in the sunlight, and making the water elow boil with foam. Another enormous block is discharged, nd, without breaking, sinks in an upright position into the water, ausing a low, thundering noise; then it rises again, sometimes 50 feet, even with the top of the wall of the glacier, while the ater rolls off its top like a cascade; then the berg topples over racefully on its side and plunges into the water with a heavy, hundering roar, like the sound of artillery or of thunder, and the

spray is shot in every direction, falling like a myriad of comets or descending rockets—the spray itself often rises as high as the top of the terminal wall; and frequently we have seen such an iceberg, after falling, wallow about in the water among the other icebergs like a huge monster. Now and then a bowlder falls with a thud. When a large iceberg falls, a series of large waves, like rings, spread themselves around the center of disturbance, and soon gracefully roll or leap, in spiral form, upon the beach close to our camp—a mile away; and when the inlet is filled with floating icebergs there is great commotion.

3. *On Sandstone dikes in California;* by J. S. Diller. Bull. Geol. Soc. of America, i, 411, 1890.—Mr. Diller describes in this paper a number of dikes, resembling closely ordinary trap-dikes, but consisting of sandstone, made chiefly of granitic material, intersecting sandstones and shales of the Cretaceous group, on the northeastern portion of the Sacramento valley. They have a general parallelism, but vary in strike from N. 20° E. in the southwestern part of the region in which they occur to N. 70° E. in the northwestern. They are from a mile to less perhaps than a hundred yards in length, and occupy joint-fissures in the rocks. Very beautiful engraved plates illustrate finely the forms and positions of the dikes. The author discusses their origin at length and attributes the fractures to earthquakes, and gives reason for believing that they were filled from below. He observes that if we regard these dikes as earthquake phenomena their gentle curvature may indicate their relation to the center of disturbance far to the southeastward in the Sacramento Valley.

4. *Annual Report of the Director of the U. S. Geological Survey for* 1886–87, vol. viii in two parts, 1060 pp. with maps and other illustrations.—Of the Memoirs that make the body of this very valuable Report those of I. C. Russell, Lester F. Ward and G. F. Becker have been already noticed in this Journal. The others are on the Lassen Peak District, by J. S. Diller; The Fossil Butterflies of Florissant, by S. H. Scudder; The Trenton Limestone as a source of Petroleum and Inflammable Gas in Ohio and Indiana, by Edward Orton; The Geology of Mount Desert Island, Maine, by N. S. Shaler. The Report contains 76 plates besides a large number of figures in the text.

5. *Hawaiian volcanoes.*—(1) *Notes from* Wm. T. Brigham, in a letter dated Honolulu, August 26th, 1890.—I have just returned from Puna, Kilauea, Mauna Loa and Mauna Kea. The latter mountain has been covered with snow on the upper region to a greater extent this summer than for many years: hence we found the tarn Waiu at the summit platform, or at the base of the terminal cinder cones, quite full; indeed two springs were flowing in on the northeast corner, while a brook of some volume flowed out on the western side. The principal cone was bare externally, except at the very base, but its crater was nearly filled with snow. At Mokuaweoweo the steam and sulphur fumes are abundant in many places. The vapor has been frequently visible

from the shore. At Kilauea I found Dana Lake had decreased since last March about one-third, but was active, while fire has appeared to the south but still in the area of depression. Several sharp earthquakes have occurred at Hilo, and one of several distinct shocks was felt by me in northern Hawaii, at Waimea, as a long continuous rumble: at Laupahoehoe on the eastern shore the shocks were more distinct than at Kau in the southern part of the island. The time of transmission from Hilo to Laupahoehoe, four miles north, was estimated by telephone at 5″.

(2) *Notes from* Ernest E. Lyman, *on an ascent to the summit of Mt. Loa*, in a letter dated Hilo, August 20.—Since Mr. Lyman's former visit to the summit crater in 1888, part of the eastern wall, near "Pendulum Peak," twenty-five yards wide and over a hundred long, had settled thirty feet or more. His descent to the bottom of the crater, on August 7th (Thursday) was here made—the distance down by estimate about four hundred feet. Steam was rising over the bottom from a number of spots not far from the base of the western wall, through the length of the crater, but the amount had diminished greatly since 1888. No other marked changes were observed. Having made his descent to Kau, he learned that on Wednesday night a dozen earthquakes had been felt there, and more severely at Hilo and in Puna, where stone walls were thrown down. At Kilauea three were felt and changes took place in Halemaumau. On the summit, nothing of the earthquake was felt by him, but his guide reported in the morning his hearing "a groaning in the ground."

Mr. Lyman collected specimens from the layers of lava constituting the walls of the summit crater, which, after being studied, will be reported upon by Professor E. S. Dana, with further citations from his letter.

6. *Brief notices of some recently described minerals.*—Neotesite.—A hydrous silicate of manganese and magnesium occurring with tephroite at the manganese mines in Grythyttan parish, Oerebro, Sweden. It is massive, cleavable and resembles red orthoclase. Hardness=5–5·5. An analysis gave:

SiO_2 29·50 MnO 40·60 Mg 20·05 FeO *tr.* H_2O 9·85=100

The general formula is $R_2SiO_4+H_2O$, or a hydrated tephroite. —L. J. Igelström in *Jahrb. Min.*, i, 257, 1890.

Ciplyte.—A supposed silico-phosphate of calcium occurring in the chalk at Ciply, and elsewhere in Belgium, associated with phosphorite. It has not been fully described.—J. Ortlier, ref. in *Bull. Soc. Min.*, xiii, 160, 1890.

Pholidolite (Folidolit).—A mineral allied to the chlorites, from Taberg in Wermland, Sweden. Occurs in small tabular twinned crystals of a grayish yellow color and pearly luster. Specific gravity 2·408. An analysis gave:

SiO_2	Al_2O_3	MgO	FeO	MnO	K_2O	H_2O
49·78	6·31	27·94	4·08	0·12	5·93	5·49=99·65.

The formula deduced is $K_2O, 12(Fe, Mg)O, Al_2O_3 13SiO_2+5H_2O$. —G. Nordenskiöld in *Geol. För. Förh.*, xii, 348, 1890.

Kaliborite.—A hydrous borate of magnesium and potassium occurring with pinnoite, which it closely resembles, near Aschersleben, Prussia. It is massive with granular structure, and specific gravity=2·05. An analysis gave:

B_2O_3 57·46 MgO 12·06 K_2O 6·48 H_2O 24·00=100

—W. Feit in *Chem. Zeitung*, 1888, 1889.

Phosphosiderite.—A hydrous ferric phosphate described by W. Bruhns and K. Busz as occurring at the Kalterborn mine near Eiserfeld. It is orthorhombic and appears in prismatic crystals, tabular parallel to the brachy-pinacoid. Hardness=3·75, specific gravity=2·76. Color peach-blosson red or reddish violet. An analysis gave:

P_2O_5 38·85 Fe_2O_3 44·30 H_2O 17·26=100·41

This corresponds to $4(FePO_4)+7H_2O$, which brings it very near strengite, to which it is also allied in form, though the two minerals appear to be distinct.—*Zeitschr. Kryst.*, xvii, 555.

Sigterite.—Described by Rammelsberg as a new member of the feldspar group. It occurs associated with the eudialyte and albite of Sigterö, Norway. Structure granular; color gray; cleavage like that of orthoclase, with polysynthetic twinning. Extinction on (001) inclined ± 3½° to 4½°, and on (010) + 16° to their intersection-edge. Specific gravity 2·600—2·6222. An analysis gave:

SiO_2 50·16, Al_2O_3 28·64, Na_2O 13·63, K_2O 3·96, FeO 1·97, CaO 0·98, MgO 0·16 ign. 0·42 = 99·92.

Deducting a little admixed augite, this becomes

SiO_2 50·54, Al_2O_3, 30·64, Na_2O 14·58, K_2O 4·24 = 100,

which gives the formula $(Na,K)_2Al_2Si_3O_{10}$, or that of an anhydrous natrolite.—*Jahrb. Min.*, ii, 71, 1890.

Åkermanite.—A lime-magnesia silicate, containing no alumina, and belonging to the tetragonal system like melilite, with which it is closely related. It is not known in nature but has been obtained by Vogt in connection with an important series of experiments upon the formation of minerals from fusion. —*Arch. Math. Nat. Kristiania*, xiii, 311, 1890.

III. Miscellaneous Scientific Intelligence.

1. *American Association for the Advancement of Science.*—The thirty-ninth meeting of the Association opened at Indianapolis on Tuesday, August 19th, nineteen years after the previous meeting at this place, Professor George L. Goodale, of Cambridge, President. The address of the retiring president, Prof. Mendenhall, discussed in a forcible way some of the relations of science to the general public.

Washington was selected as the place of meeting in August, 891. The officers elected were as follows: *President*, Albert B. Prescott of Ann Arbor. *Vice-presidents* of the Sections, E. W. Hyde, Mathematics and Astronomy; F. E. Nipher, Physics; R. C. Kedzie, Chemistry; Thomas Grey, Mechanical Science and Engineering; J. J. Stevenson, Geography and Geology; T. M. Coulter, Biology; J. Jastrow, Anthropology; S. Dana Horton, Economic Science and Statistics.

The American Committee of the International Congress of Geologists, appointed by the American Association, as explained on page 166 of this volume, was discharged.

Sections A, Mathematics and Astronomy, and B, Physics.

E. H. Moore: The Problem, to circumscribe about a conic a triangle which hall be inscribed in a triangle which is itself inscribed in the conic, and a certain uestion concerning two binary cubics.

J. D. Warner: A method of testing for primes.

J. A. Brashear: Recent photographs of the moon by direct enlargement. he great Lick Spectroscope. Recent studies in the ultra-violet spectrum. A ew self-regulating photometer.

Frank H. Bigelow: Further study of the solar corona. Terrestrial magnetism.

C. H. Rockwell: Some personal experiences on the expedition to Cayenne, rench Guinea, to observe the eclipse of 22d Dec., 1889.

Cleveland Abbe: Some results of observations made during the recent U. S. xpedition to the west coast of Africa. Aberration methods of determining the titudes and motions of the clouds. The marine nephoscope.

E. D. Preston: Magnetic and gravity observations on the west coast of Africa nd at some islands in the Atlantic.

R. S. Woodward: The effects of the atmosphere and oceans on the secular ooling of the earth.

Thomas Gray: Earthquake and volcanic action in Japan. A new transmission ynamometer. Exhibition of seismograph.

T. C. Mendenhall: Use of the magnetograph as a seismoscope. New metric andards.

T. Russell: Prediction of cold waves from Signal Service weather maps.

F. E. Nipher: Surface integrals in meteorology. Method of measuring the ectrical resistance of liquids.

J. Trowbridge and W. C. Sabine: Electrical oscillations in air.

A. E. Dolbear: On maximum temperatures.

E. W. Morley: Determination of the tension of the vapor of mercury at ordi-ary temperatures.

O. T. Sherman: Exhibition of Verns' photographs in natural colors.

E. W. Morley and H. T. Eddy: Report on the velocity of light in a mag-etic field.

Wm. A. Rogers: Description of the equal-temperature room in the observa-ory and physical laboratory of Colby University. Is thermometry an exact sci-ice? Exhibition of a combined meter with subdivisions to 2mm. and a yard ubdivided to tenths of inches, both being standards at 62 deg. Experimental etermination of the time required for water to pass from 42° to 72° in a constant r temperature. Evaporation as a distributing agent in a determination of the mperature of water. Experimental determination of the rate of change in un-erground temperatures at a depth of nine feet by means of a flow of water at a onstant level.

E. L. Nichols and B. W. Snow: Radiation at a red heat; preliminary note n the radiation from zinc oxide.

Eli W. Blake: Exhibition of plans and sketch of the new physical laboratory, Wilson Hall," of Brown University, Providence, R. I.

H. S. Rodgers and Thomas French, Jr.: On certain electric phenomena in Geissler tubes.

W. F. Durand: Magnetic and electric phenomena viewed as manifestations of strain.

E. B. Rosa: The specific inductive capacity of electrolytes.

G. W. Hough: Discussion of the formulas indicating the work of an electric motor.

A. L. Arey: Plan for a resistance box.

J. E. Denton: On the specific heat of brine near 0° Fahr.

W. H. Hammon: Observations taken in four balloon ascents.

D. P. Todd: On a form of pneumatic commutator and its use in the automatic operation of physical apparatus.

F. W. Very: On the phosphoric lamp.

P. H. Van der Weyde: On the advisability of applying the C. G. S. system of modern electricians to the principles of elementary mechanics.

D. T. Smith: Flow and friction of fluids in open channels—theory of streams.

Thos. French, Jr.: Actinic action of electrical discharge.

Morris Loeb: Is chemical action influenced by magnetism?

A. Tuckerman: Index to the literature of thermodynamics.

C. A. Oliver: Description of a series of tests for the detection and determination of sub-normal color-perception, designed for use in railroad service.

Wellington Adams: Ampere-meter for feeble alternating currents: the Farado-meter.

Ernest Merritt: Note on certain peculiarities in the behavior of a galvanometer when used with a thermopile.

Section C. Chemistry.

H. W. Wiley: Knorr's extraction apparatus. Some new forms of apparatus for drying substances in an atmosphere of hydrogen. Apparatus for recovering highly volatile solvents. Pine tree sugar (*Pinus Lambertiana*). Pine tree honey dew and pine tree honey.

H. W. Wiley and H. E. L. Horton: On the alkaloidal principles present in the seed berries of *Calycanthus glaucus.*

H. W. Wiley and Walter Maxwell: Mucilaginous, nitrogenous and dysmorphous carbohydrate bodies in the sorghum plant.

Walter Maxwell: On the nitrogenous elements present in cattle food prepared from the cotton seed meal. On the method of estimation of the fatty bodies in vegetable organisms and the behavior of the glycerides and lecithines during germination.

G. L. Spencer: Apparatus for evaporating in vacuo. The estimation of theine in teas.

A. E. Dolbear: On chemism—an inquiry into the conditions which underlie chemical reactions.

A. E. Knorr: Apparatus for determining solubilities.

F. W. Clarke: Experiments on the chemical constitution of the silicates

J. L. Fluelling: Constant ratio between a reducing sugar and the amount of copper set free, determined gravimetrically.

Hubert Edson: Preservation of sugar solutions and influence of basic and normal lead acetate on analysis thereof.

H. E. L. Horton: Study of Fehling solution in estimation of sugars.

H. A. Huston: Action of ammonium citrate on high grade aluminium phosphate.

E. H. S. Bailey: On the minerals constituting a meteorite found in Kiowa county, Kansas.

J. U. Nef: Constitution of Benzoquinone.

P. C. Freer: The action of sodium on acetone and the constitution of aliphatic ketones.

E. A. von Schweinitz: Study of the composition of Osage Orange leaves. A new ptomaine. Preliminary study of the ptomaines from the culture liquids of the hog cholera germ.

W. E. STONE: Occurrence of the pentaglucoses. Reduction of Fehling's solution by arabinose. Quantitative estimation of the pentaglucoses in the presence of other carbohydrates.

S. B. NEWBURY: Action of alcohol upon aldehydes. New chemical laboratory of Cornell University.

C. L. SPEYERS: Some thoughts on electromotive force.

W. O. ATWATER and H. B. GIBSON: Heats of combustion of certain organic bodies.

H. A. HUSTON: Analysis of a Lycoperdon. Notes on certain reactions for pyrotoxicon.

F. P. VENABLE: The proper standard of the atomic weights.

E. W. MORLEY: Determination of the volumetric composition of water. Ratio of the density of oxygen and hydrogen.

W. A. NOYES: Atomic weight of oxygen. Unit for the atomic weights.

T. H. NORTON: Improved forms of gas generators. A constant and easily regulated chlorine generator. Derivatives of dinitro-a-naphthol. A soluble compound of hydrastine with mono-calcium-phosphate. Application of the potassium chlorate method for the determination of sulphur to the analysis of horn. On a new method of preparing benzine-sulfonic-bromide, etc.

Section D. Mechanical Science and Engineering.

THOMAS GRAY: A new transmission dynamometer. Preliminary experiments in the resistance of metals to cutting. Machine for testing tortional stiffness. Diagramming apparatus for use in testing materials. Dynamometer for measuring the resistance of cutting tools.

WM. A. ROGERS: Construction of a precision screw eight feet in length. Simple method of subdividing index wheels into 1,000 parts.

WM. KENT: Standard formula for efficiency of steam engines.

O. T. BEALE: New principles of mechanism shown by experiment with spiral gears.

H. C. JONES: Efficiency of locomotive link motion compared to automatic cut-off valve gear of modern high speed engines.

G. M. BOND: Effect of internal strains in hardened steel.

OBERLIN SMITH: The principal element of waste in machine shops.

T. D. PARET: Money value of solid emery wheel.

J. E. DENTON: Use of the locomotive as an apparatus for testing cylinder oils. Results of test of performance of 75-ton ammonia-compression refrigerating machine.

W. J. BEALE: Structure of woods as viewed in their cross sections.

H. F. DURAND: Note on graphical construction of crank effort diagram.

M. A. HOWE: Results of tests of strength of sewer pipe.

ST. JOHN DAY: A vortex automatic lubricator for high speed shafts.

Section E. Geology and Geography.

H. T. FULLER: Preservation of glaciated rocks.

J. T. SCOVELL: An old channel of the Niagara river.

G. W. HOLLEY: Niagara—a few last words in reply to Mr. G. K. Gilbert's history of the Niagara river.

J. T. CAMPBELL: Local deposit of glacial gravel found in Park county, Ind. Topographical evidence of a great and sudden diminution of the water supply in the ancient Wabash.

JOSEPH MOORE: Concerning some portions of *Castoroides Ohioensis*, Foster, not heretofore known.

H. CARRINGTON BOLTON: The "Barking Sands" of the Hawaiian Islands. Occurrence of sonorous sand on the Pacific coast of the U. S.

E. T. COX: Floridite, a new variety of phosphorite found in Florida.

W J MCGEE: The Columbia formation in the Mississippi embayment.

C. A. WHITE: Paleontological and geological relation of closely similar fossil forms.

Theo. B. Comstock: Crystalline rocks of Central Texas. Geology of the Wichita Mountains, Indian Territory. Silurian system and its geanticline in Central Texas and Indian Territory.

P. H. Van der Weyde: Glacial action considered as a continuous phenomenon, having shifted from one locality to another.

R. T. Hill and James S. Stone: Geology of Indian Territory south of Canadian river.

N. H. Winchell: What constitutes the Taconic mountains?

James M. Safford: The formations and artesian wells of Memphis, Tenn.

T. C. Chamberlin: Progress in morainic mapping.

Arthur Winslow: Remarks on construction of topographic maps for geologic reports. Occurrence of pegmatite in Central Missouri.

Edward Orton: Amount of natural gas used in glass manufacture.

J. E. Siebel: Differentiation of subterranean water supplies.

C. W. Hall: Some of the qualifying conditions of successful artesian well boring in the northwestern States. A notable dike in the Minnesota River Valley.

T. C. Hopkins: Topographic features of Arkansas marbles.

R. A. F. Penrose, Jr.: The origin of the manganese ores of Northern Arkansas and its effect on the associated strata.

L. S. Griswold: The Novaculites of Arkansas.

E. W. Claypole: Subsidence and deposition as cause and effect.

H. E. Pickett and E. W. Claypole: The recent explosion of natural gas in Shelby county, Ind.

O. A. Derby: The Bemdego (Brazil) meteorite. New method of searching for rare elements in rocks. Genesis of certain magnetites. Nepheline-bearing rocks in Brazil.

Section F. Biology.

Sereno Watson: Relation of the Mexican flora to that of the United States.

J. M. Coulter: Distribution of the North American Umbelliferæ. Distribution of North American Cornaceæ.

Stanley Coulter: Forest trees of Indiana.

J. N. Rose: Notes upon plants collected by Dr. Ed. Palmer at La Paz, Lower California, in 1890.

W. P. Wilson: The development and function of the so-called cypress-"knees," with a consideration of the natural habitat of the tree.

H. L. Bolley: Potato scab, a bacterial disease.

N. L. Britton: Preliminary note on the genus Rhynchospora in North America. Rusbya, a new genus of Vacciniaceæ from Bolivia. Notes on a monograph of the genus Lechea. The general distribution of North American plants.

Burt G. Wilder: Lack of the distance sense in the prairie dog. Exhibition of diagrams illustrating the formation of the human sylvian fissure.

G. S. Hopkins: Structure of the stomach of *Amia calva.*

T. B. Spence: Support for the *Chorda tympani* nerve in Felidæ.

Herbert Osborn: External termination of the urethra in the female of Geomys Bursorius.

F. V. Coville: Work of the botanical division of the department of Agriculture.

C. S. Minot: Account of the marine biological laboratory at Wood's Holl. Differentiation of the primitive segments in vertebrates. Morphology of the blood corpuscles. Disappearance of the Decidua reflexa.

A. J. Cook: Food of bees.

C. L. Herrick: A case of morbid affection of the eye in a cat.

B. T. Galloway: Life history of *Uncinula spiralis.* Preliminary notes on a new and destructive oat disease.

Theobald Smith: Variability of disease-germs.

Simon H. Gage and H. W. Norris: Notes on the amphibia of Ithaca.

Simon H. Gage and Susanna P. Gage: Changes in the ciliated areas of the alimentary canal of the Amphibia during development, and relation to the mode of respiration.

S. H. GAGE: Combined aerial and aquatic respiration in Amphibia, and the functions of the external gills in forms hatched on land.

J. K. HOWELL: Trimorphism of *Uromyces Trifolii.*

CLARENCE M. WEED: Harvest spiders of North America.

E. D. COPE: Structure of certain paleozoic fishes.

L. H. PAMMEL: Seed coats of the genus Euphorbia.

D. H. CAMPBELL: Method of growth of the prothallia of the Filicineæ, with reference to their relationships. Contributions to the life history of Isæus.

V. M. SPALDING: Development of the sporocarp of *Griffithsia Bornetiana.*

LUCIEN M. UNDERWOOD: Distribution of Hepotiæ of North America.

BYRON D. HALSTED: The migration of weeds.

W. J. BEAL: Geographical distribution of North American grasses.

H. E. WILLIAMS: On the plates of *Holonema rugosa.*

W. J. BEAL and T. W. TUOMEY: Continuity of protoplasm through the cell-walls of plants.

J. B. STEERE: Distribution of land birds in the Phillippine Islands.

J. C. ARTHUR and H. L. BOLLEY: The specific germ of the Carnation disease.

W. P. WILSON: Desirability of establishing a Biological station on the Gulf of Mexico.

W. R. LAZENBY: Crystals in certain species of the Arum family.

C. W. HARGITT: *Isopyrum biternatum.*

Section H. Anthropology.

H. W. HENSHAW: Indian origin of maple sugar.

W. K. MOOREHEAD: Fort Ancient.

W. H. HOLMES: Aboriginal stone implements of the Potomac valley.

R. T. COLBURN: Suggestion for a Pan-American as precursor to an universal language.

J. MULLER: Dialectic studies in the Swedish province of Dalecarlia. Peculiar effects of one-sided occupations on the anatomy and physiology of man.

F. W. PUTNAM: Notice of a sin ular earth-work near Fosters, Little Miami Valley, Ohio. On an ancient hearth in the Little Miami Valley.

B. G. WILDER: Exhibition of diagrams of the brains and medisected heads of man and a chimpanzee.

C. C. ABBOTT: Exhibition of a bone image from Livingston county, N. Y. Exhibition of gold beads of Indian manufacture from Florida and New Jersey.

J. JASTROW: A study of mental statistics.

O. T. MASON: Arts of modern savages for interpreting Archæology.

H. D. GARRISON: The form of the external ear.

H. M. STOOPS: Preliminary steps to an Archæological map of Franklin Co., Indiana.

E. D. COPE: The relation of mind to its physical basis.

J. W. SPENCER: Remarks upon the mounds of Sullivan county, Indiana.

ZELIA NUTTALL: On the atbatl or spear-thrower of Ancient Mexico.

ANITA NEWCOMB MCGEE: The evolution of a sect.

H. N. RUST: On obsidian instruments of California. The basket-mortar of Southern California. The adze.

Section I. Economic Science and Statistics.

S. DANA HORTON: American money, past and present. Instruments of valuation or the nature of money units.

LAURA OSBORN TALBOT: Natural resources of Loudon county, Va. Economic value of the energy of neglected children.

B. E. FERNOW: The forest as a national resource.

M. MILES: Biological factors in nutrition of farm crops.

EDWARD ATKINSON: The right application of heat to the conversion of food material.

JACOB REESE: Refrigerating power of trees.

WM. S. HILL: Constitutionality of our national economic policy.

EDWARD ORTON: Municipal corporations and natural gas supply.
JAMES H. KELLOGG: Utilization of surplus labor.
MARY HENMAN ABEL and ELLEN H. RICHARDS: Hygienic advantage of the sterilization of milk and its best methods.
WM. H. HALE: Ethics of strikes.
GEO. W. HOLLEY: Floods of the Mississippi and how to prevent them.

2. *British Association at Leeds.*—The meeting at Leeds commenced its sessions on the 3d of September. The inaugural address of the President, Sir Frederick Augustus Abel, treated of the practical achievements of physical science during the past 32 years—the interval since a former meeting at Leeds.

The address of the President of the Association and those of the Vice-Presidents, together with full reports of the papers presented at the meeting, will be found in the successive numbers of Nature, commencing with that for September 4. This excellent weekly Journal of Science should be in the hands of all interested in science and its progress. Its semi-annual volumes begin on May 1 and Nov. 1.

3. *An American Geological Railway Guide*, giving the geological formation at every railway station, with altitudes above mean tide-water, notes on interesting places on the routes, and a description of each of the formations; by JAMES MACFARLANE. Second edition, revised and enlarged, edited by James R. Macfarlane. 426 pp. New York, 1890 (D. Appleton & Co.).—This new edition of Dr. Macfarlane's excellent hand-book for geologists and tourists, on which he was working before his death in 1885, has been edited by his son with much care, producing a valuable thesaurus and compendium of information concerning the geology, the mineral deposits, and the best localities for collecting fossils and examining geological sections in Canada, the United States and Mexico. The scope of the book is well seen from the title page, as above quoted. Its reliability is guaranteed by the names of the geologists of the several State, United States, and Canadian geological surveys, who have supplied full notes of their respective fields of investigation. W. U.

4. *Royal Society of N. S. Wales.*—Vol. xxiii, Part 2, of the Journal and Proceedings contain, covering 160 pages, a list of the marine and freshwater Invertebrate fauna of Port Jackson and the neighborhood, by I. Whitelegge; on the occurrence of platinum in a feldspathic vein in the Broken Hill district; on the Australian Aborigines, and other papers.

5. *Smithsonian Miscellaneous Collections*, no. 741: Index to the Literature of Thermodynamics, by A. Tuckerman. 240 pp. 8vo. 1890.

6. *Verzeichniss der Schriften über Zoologie von Dr. O. Taschenberg, of Halle.*—The eighth "Lieferung," signatures 281–320, of this important zoological bibliography has been issued by W. Engelmann. It finishes the Hymenoptera and commences the Coleoptera.

THE

AMERICAN JOURNAL OF SCIENCE

[THIRD SERIES.]

ART. XLIV.—*Further Study of the Solar Corona;* by FRANK H. BIGELOW.*

IT was one of the proposed objects of the U. S. Eclipse Expedition to West Africa, in December, 1889, to make an effort to secure some photographs of the Solar Corona on a large scale, in order that certain measurements might be taken which would test fully the validity of the equation that I have assigned to the coronal curves. Inasmuch as we failed to obtain the desired pictures, in consequence of the clouds that prevailed during the minutes of totality, I have since my return to the United States made a series of measures upon photographs of the Coronas of 1878, July 29, 1889, Jan. 1, and 1889, Dec. 22, which have been generously placed at my disposal by the Superintendent of the Naval Observatory, and by the Directors of the Harvard College and the Lick Observatories respectively. I am also greatly indebted to Professor William Harkness for allowing me to use the Transit of Venus Measuring Engine, by Stackpole, and for all needful assistance. Six pictures have been measured, two La Junta negatives of July 26, 1878, taken by Professor Hall, two Creston negatives of July 26, 1878, by Professor Harkness, one positive of Jan. 1, 1889, by Professor W. H. Pickering at Willows, Cal., and one negative by Mr. Burnham at Cayenne, S. America, Dec. 22, 1889. As the computations are quite heavy the results of only one are presented with this paper.

* Read before the American Association at Indianapolis, August 22d, 1890.

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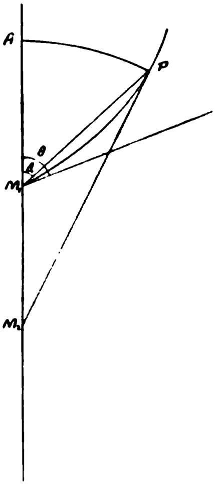
The Equation of the Lines of Force.

The equation to be investigated may be derived as follows. Without raising the question of the physical constitution of masses of matter exhibiting the phenomena, we may understand by a polarized sphere, one in which magnetic or electrical potentials are to be referred to one general axis; or if not symmetrical, one in which the positive potential is distributed about one pole, and the negative potential about another pole, the poles themselves being the intersection of two nearly opposite axes with the spherical surface. The potentials at any points in space may be discussed as if the actual distribution of polarized matter were replaced (1) by a small magnet at the center of the sphere, the direction of the axes coinciding, or (2) by a surface distribution whose density varies from a maximum at the poles, with the cosine of the angle of the polar distance, to zero at the corresponding equatorial plane. The former is the result of bringing two equal masses of opposite signs very near each other at the center of the sphere, and the latter is the lamellar distribution. They each give the same equations for lines of force and equipotential surfaces respectively.

1.



Equation of lines of force and equipotential surfaces.

Let M_1, M_2 be any two electrified masses connected by an axis of reference; join any point P with M_1 and M_2 by straight lines, and with the axis A by any curve; across a cylindrical surface generated by AP, the flow of force from M_1 is N_1, and from M_2 is N_2, the constant total force being $N_1+N_2=N$. Let PM_1 be the curve formed by the locus of the point that will keep N the same while the position of P varies in a plane, and let the tangent to this curve at the point M_1 make the angle θ with the axis; N is called the order of a line of force. Considering a single mass, the flow of force corresponding to the circular zone whose angle at the summit is 2θ, is proportional to the cap whose height is $1 - \cos\theta$.

$$\frac{N}{4\pi M} = \frac{1-\cos\theta}{2} \qquad N = 2\pi M\,(1-\cos\theta).$$

Introducing this into the equation and limiting the case to equal masses of opposite signs, we obtain,

$$2\pi M_1(1-\cos\theta_1)+2\pi M_2(1-\cos\theta_2) = 2\pi M(1-\cos\theta) = N;$$

whence, $$M_1\cos\theta_1+M_2\cos\theta_2 = M_2+M_1\cos\theta.$$

and by our special case,

$$\cos\theta_1 - \cos\theta_2 = 1 - \cos\theta = \frac{N}{2\pi M}.$$

Now if these masses be brought infinitely near together, the θ_1 and θ_2 will differ by an infinitely small amount, h; we have,

$$\cos\theta_1 - \cos\theta_2 = 2\sin\frac{\theta_1+\theta_2}{2}\sin\frac{\theta_1-\theta_2}{2}.$$

$$= 2\sin\theta . \frac{h}{2} = \sin\theta . h.$$

$$= \sin\theta . \frac{2a\sin\theta}{r} = \frac{2a}{r} . \sin^2\theta,$$

where a is the distance apart of the particles, and r the mean distance of the point P from M_1M_2.

Hence, $$N = 2\pi\,(2Ma)\,\frac{\sin^2\theta}{r},$$

which is the equation of a line of force.

Term $2a . M$ is the moment of the system, and if we choose to deal only with the outside of a large sphere, it is equivalent to the layers of gliding on a polarized sphere, and these again to $u\sigma_0$, where u is the volume of the sphere $\frac{4}{3}\pi R^3$, and σ_0 of the surface density at the poles. Therefore,

$$N = \frac{8\pi}{3} . (\pi R^3\sigma_0)\frac{\sin^2\theta}{r}.$$

From this equation we may draw typical lines of force by assuming $\pi R^3\sigma_0$ equal to unity, and this is the best form for use until we have the means of determining the value of σ_0; thus we finally get,

$$N = \frac{8\pi}{3} . \frac{\sin^2\theta}{r}.$$

The Equation for Equipotential Surfaces.

The potential of a mass M_1 at a distance r_1 is, $V_1 = \frac{M_1}{r_1}$, and of a Mass M_2, at a distance r_2 is, $V_2 = \frac{M_2}{r_2}$. If these masses are equal and of opposite signs, at the point of intersection of r_1 and r_2,

$$V = V_1 + V_2 = \frac{M_1}{r_1} - \frac{M_2}{r_2} = M\left(\frac{1}{r_1} - \frac{1}{r_2}\right).$$

These surfaces are of an ovoidal form, with a single sheet, tending to merge into spheres in proportion as they approach the centers of action.

If the two points are located infinitely near together,

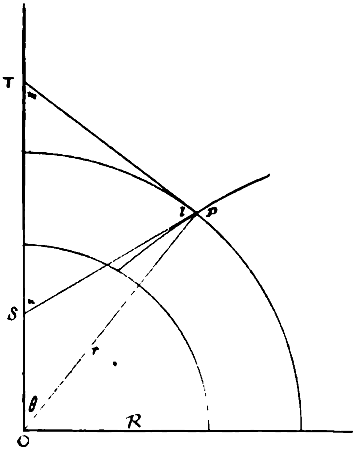
$$V = M . \frac{r_2 - r_1}{r_1\, r_2} \text{ becomes } V = M . \frac{r_2 - r_1}{r^2} = M . \frac{2a . \cos\theta}{r^2}.$$

An equivalent of the moment of the system $2a\text{M}$ is as before, $2a\text{M} = \frac{4}{3}\pi\text{R}^3\sigma_0$, and the value of the potential at any point outside the sphere $(r . \theta)$ is $V = \frac{4}{3}\pi\text{R}^3\sigma_0 . \frac{\cos\theta}{r_2}$.

Typical forms of the curves may be found by employing simply the expression, $V = \frac{\cos\theta}{r_2}$.

Gauss' Theorem of Polar intercepts.

2.



For Gauss' Theorem.

On the sphere whose radius is R, construct a line of force one of the points being $(r . \theta)$. Through $(r . \theta)$ draw a circle with radius r, a tangent to this circle making an angle m with the polar axis, and also a tangent to the line of force making the angle n with the axis. The triangle PTS will have the interior angles l, m, n, at corresponding vertices. Now,

$$\text{PS} . \cos l = \text{OS} . \sin\theta$$

$$\text{PS} . \sin l = \text{TS} . \cos\theta$$

$$\text{Hence, OS} . \tan l = \text{TS} . \cot\theta = \text{TS} . \frac{\tan l}{2},$$

as can be proved by the discussion of the resolved forces. Therefore,

$$\text{ST} = 2\text{OS, and OT} = 3\text{OS}.$$

The intercept from the center cut off by the force tangent is one-third the intercept cut off by the circle tangent.

This formula is also convenient for computing the inclination of the line of force to the normal as it leaves the surface of the sphere. If the lines are seen on the section of the meridian plane perpendicular to the line of vision, it applies directly, $\tan l = 2 \cot\theta = 2 \tan m$. If the angle actually seen is on any other meridian section, the projected value of the angle must be converted from its oblique to the perpendicular plane, by turning it through the angle a. Since l is the angle of the line of force with the tangent, $90-l$ is its angle with the normal.

If l^1 is the apparent measured angle of inclination of a line with the radius extended, then $\tan l = \tan l^1 \sec a \sec \theta$.

In a preceding paper I applied this theorem to some photographs of coronal lines, finding a strong tendency to represent the intercept ratio in the four quadrants, and yet with such marked exceptions as might well lead to the interpretation that the agreement was fortuitous between the graphical representations of the mathematical formulæ and the natural phenomenon. It is now my object to carry out the comparison with considerable accuracy, paying regard to the distortions of the coronal lines as produced by the perspective effects. It may be possible sometime to include the corrections due to differential refraction, non-coincidence of the centers of the disks of the Sun and the Moon with the axis of vision, and such others as exist, but at present they must be omitted because the photographs used are too small to permit settings for measures within these limits of precision.

The Negative here discussed is

Marked No. 16, July 29, 1878, La Junta, Col., by Professor Asaph Hall. It was taken with a Dallmeyer's patent portrait and group lens, size No. 8 D; effective focal length 37·89 inches, clear aperture 6·0 inches; the plates were the dry washed emulsion; the size of the image of the Moon's disk is 0·362 inch, but the limb is not circular because of the Moon's motion in right ascension. The measurements were made by centering the image so that in revolving the table the edge of the disk remained tangent to the micrometer thread. Having selected the polar line of the corona by inspection, the readings of the N. and S. poles respectively were taken; then as many settings on individual rays as was practicable were made, the polar angle and the distance in micrometer revolutions read. The corresponding values of r and θ were made the basis of the computation.

North Polar Setting 251° 40′.

South Polar Setting 244° 30′.

The angle from the N. Pole through the east to the S. Pole is 172° 50′.

The North Pole lies 1° 10′ east of Sun's Axis.

The South Pole lies 6° 0′ east of Sun's Axis.

The reading for the North Pole is 7·55 divisions.

The reading for the South Pole is 7·45 divisions.

Correction for micrometer readings is for N. P. readings −1·00; for S. P. reading −0·90. The diameter of the disk is 13·10 divisions. The factor for reduction to the unit radius is 6·55.

A complete record of the readings is given in table No. 1.

TABLE I.

S. W. Quadrant.			S. E. Quadrant.		
Ray.	Radius.	Circle.	Ray.	Radius.	Circle.
	d			d	
1	7·55	254° 19′	1	7·55	250° 51′
	9·32	254 36		9·20	249 45
	10·50	255 0		10·70	249 20
2	7·50	256 1	2	7·55	250 33
	9·45	258 31		8·90	248 8
	10·90	260 12		10·20	244 0
3	7·55	258 30	3	7·58	242 33
	9·45	261 17		8·92	237 0
	10·87	262 56		10·30	233 10
4	7·55	260 40	4	7·56	237 18
	9·03	263 17		9·40	230 52
	10·60	265 38		11·25	223 8
5	7·55	264 41	5	7·57	233 26
	9·00	272 23		9·55	225 49
	10·12	276 5		10·80	220 36
6	7·60	276 52	6	7·56	230 48
	9·40	285 17		10·00	220 8
	10·52	290 41		11·80	213 50
7	----	--- --	7	7·58	220 26
	9·10	290 42		9·60	213 43
	10·28	299 8		11·18	208 12
8	----	--- --	8	7·66	217 2
	9 60	299 10		9·62	208 6
	11·10	307 38		11·16	201 23
	12·35	314 32		12·68	194 44
			9	7 57	210 0
				9·85	201 36
				11·85	192 37

N. E. Quadrant.			N. W. Quadrant.		
	d			d	
1	7·45	70° 50′	1	7·50	63° 15′
	9·00	73 38		9·10	62 30
	10·70	75 0		10·45	60 0
2	7·45	74 32	2	7·45	61 13
	9·30	77 52		9·20	59 0
	11·00	81 0		10·52	57 46
3	7·45	78 8	3	7·45	59 10
	9·33	81 36		9·20	55 29
	10·50	83 26		10·95	51 29
4	7·45	81 20	4	7·45	55 32
	9·33	87 51		9·44	50 25
	10·72	91 12		10·94	45 6
5	7·45	86 5	5	7·45	51 48
	9·20	90 57		9·30	44 16
	10·80	95 58		11·10	35 8
				12·24	31 4
6	7·45	93 47		13·52	26 56
	9·60	100 30			
	10·90	105 1	6	----	-- --
				9·20	26 56
7	7·45	103 1		11·56	13 16
	9·45	111 18		13·10	5 2
	10·91	115 48			
	----	--- --			
	9·10	122 50			

Table II.

S. W. Quadrant.

Ray.	log *r*.	θ.	N.
1	0·00000	2° 39′	0·018
	0·10388	2 56	0·017
	0·16148	3 20	0·019
2	9·99667	4 21	0·049
	0·11062	6 51	0·092
	0·17940	8 32	0·122
3	0·00000	6 50	0·119
	0·11062	8 37	0·146
	0·17808	11 16	0·212
4	0·00000	9 0	0·205
	0·08848	11 37	0·277
	0·16603	13 58	0·333
5	0·00000	13 1	0·425
	0·08685	20 43	0·858
	0·14375	24 25	1·026
6	0·00330	25 12	1·507
	0·10804	33 37	2·001
	0·16240	39 1	2·284
7	----	----	----
	0·09225	39 2	2·688
	0·15131	47 28	3·211
8	----	----	----
	0·11826	47 30	3·469
	0·18808	55 58	3·731
	0·23876	62 52	3·829

S. E. Quadrant.

Ray.	log *r*.	θ.	N
1	0·00000	0° 49′	0·002
	0·09757	1 55	0·007
	0·17053	2 20	0·009
2	0·00066	1 7	0·003
	0·08139	3 32	0·026
	0·14755	7 40	0·106
3	0·00208	9 7	0·209
	0·08249	14 40	0·444
	0·15224	18 30	0·594
4	0·00066	14 22	0·515
	0·10804	20 48	0·824
	0·19448	28 32	1·229
5	0·00133	18 14	0·817
	0·11573	25 51	1·220
	0·17053	31 4	1·506
6	0·00066	20 42	1·200
	0·13800	31 32	1·670
	0·21718	37 50	1·912
7	0·00199	31 14	2·242
	0·11826	37 57	2·413
	0·19150	43 28	2·557
8	9·00723	34 38	2.655
	0·11927	43 34	3·024
	0·19065	50 17	3·195
	0·25120	57 26	3·261

N. E. Quadrant.

Ray.	log *r*.	θ.	N.
1	0·00000	3 40	0·034
	0·09225	0 52	0·001
	0·17499	1 30	0·004
2	0·00000	0 2	0·000
	0·10804	3 22	0·023
	0·18808	6 30	0·069
3	0·00000	3 38	0·037
	0·10959	7 6	0·099
	0·16603	8 56	0·138
4	0·00000	6 50	0·119
	0·10959	13 21	0·346
	0·17587	17 42	0·517
5	0·00000	11 35	0·338
	0·10284	16 27	0·530
	0·17940	21 28	0·742
6	0·00000	19 17	0·914
	0·12328	26 00	1·212
	0·13800	30 31	1·572
7	0·00000	28 31	1·909
	0·11573	36 48	2·302
	0·18419	41 18	2·388
8	-----	----	----
	0·09757	*48 20*	3·736
	0·17543	*56 9*	3·849
	0·25638	*61 40*	3·597

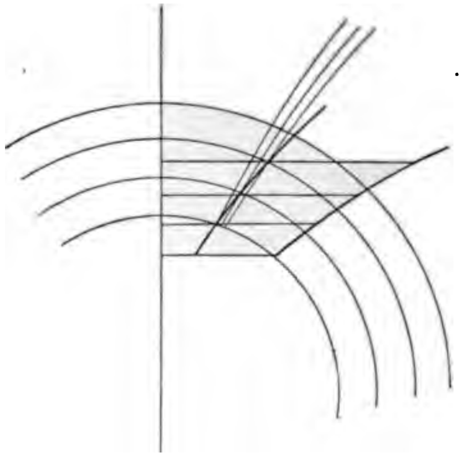
N. W. Quadrant.

Ray.	log *r*.	θ.	N.
1	0·00330	11 15	0·199
	0·09757	12 0	0·289
	0·16376	14 30	0·360
2	0·00000	13 17	0·442
	0·10284	15 30	0·472
	0·16694	16 44	0·473
3	0·00000	15 20	0·589
	0·10284	19 1	0·702
	0·18593	23 1	0·835
4	0·00000	18 58	0·885
	0·11522	24 5	1·056
	0·18549	29 24	1·317
5	0·00000	22 42	1·248
	0·10804	30 14	1·657
	0·19236	39 22	2·164
	0·23837	43 26	2·287
	0·28825	47 34	2·347
6	----	----	----
	0·10284	47 35	3·604
	0·21152	61 14	3·956
	0·27012	69 28	3·940

The first process was to substitute the resulting values of $r.\theta$ in the formula for the lines of force, $N=\frac{8\pi}{3}\cdot\frac{\sin^2\theta}{r}$. The computed values are collected in table No. II.

It is observed that the values of N derived from measures on the same ray are not equal. If all the circumstances are fully accounted for, they would be alike and the angle θ would show the same polar distance for the beginning of the line N. But it is seen that there is a marked progression in these values, which indicates that some systematic error adheres to the work. An inspection of the case suggests that the projection of the ray from its position in space upon the apparent plane of the disk must be taken fully into account, for it is not probable that any large number of the visible rays start from the body of the sun in the very plane of the disk. To such rays the formula should have applied. The problem is therefore to discover at what point of the sphere each ray originates, and to assign angular coördinates to the same.

3.



Ray projected across a series of N-lines.

The figure illustrates how a ray springing from the surface of the sun is seen projected so as to lie across a series of true N-lines represented as proceeding from the disk. What was computed in the last operation is in fact the particular N-line that passed through the point as measured in its projected situation. We must now discover a means of determining through what angle a the plane of the ray N must be rotated in order to be seen on the plane of the disk. Also we must carefully distinguish between the pole of the corona and the selected pole on the disk, for although these two poles lie in the same plane whose position angle with the sun's axis at the center of the disk has already been given, yet the angular distance of the coronal pole from the plane of the disk, being at this time unknown, has an immediate effect upon the angle a that is being sought. All the planes containing the rays intersect in the coronal axis, and if this was in the plane of the disk the rotation angle a would be the same for all measured points on the ray; otherwise a measured at the pole on the disk will exhibit a progression of values as we pass along the ray. As each quadrant has been considered independently, no effort was made to generalize the angle α, but it is counted from the plane of the disk to the plane passing through the point on the ray, at the axis of intersection of the planes through the center of the sun.

$$N = \frac{8\pi}{3} \cdot \frac{\sin^2\theta}{r}.$$

Let $x_1 = r_1 \sin\theta_1$ and $y_1 = r_1 \cos\theta_1$, the accents indicating the first point that is measured on a ray.

$$r = \sqrt{x^2+y^2} \quad \sin^2\theta = \frac{x^2}{r^2} = \frac{x^2}{x^2+y^2}.$$

$$N = \frac{8\pi}{3} \cdot \frac{x^2}{(x^2+y^2)^{\frac{3}{2}}}.$$

As a first approximation, assume that the axis of the planes of rotation lies in the plane of the apparent disk; hence by rotating a ray from the edge of the disk to its actual position, the values of y are unchanged, while those of x are reduced. The radius of revolution is $x_1 = r_1 \sin\theta_1$, therefore $x = x_1 \sec\alpha$.

Substituting, $$N = \frac{8\pi}{3} \cdot \frac{r_1^2 \sin^2\theta_1 \sec^2\alpha}{(r_1^2 \sin^2\theta_1 \sec^2\alpha + r_1^2 \cos^2\theta_1)^{\frac{3}{2}}}.$$

Since the points are on the same ray, we take

$$\frac{r_1^2 \sin^2\theta_1}{(r_1^2 \sin^2\theta_1 \sec^2\alpha + r_1^2 \cos^2\theta)^{\frac{3}{2}}} = \frac{r_2^2 \sin^2\theta_2}{(r_2^2 \sin^2\theta_2 \sec^2\alpha + r_2^2 \cos^2\theta_2)^{\frac{3}{2}}}.$$

$$\frac{(x_2^2 \sec^2\alpha + y_2^2)^{\frac{3}{2}}}{(x_1^2 \sec^2\alpha + y_1^2)^{\frac{3}{2}}} = \frac{x_2^2}{x_1^2}.$$

$$\sec^2\alpha = \frac{x_2^{\frac{4}{3}} y_1^2 - y_2^2 x_1^{\frac{4}{3}}}{x_1^{\frac{4}{3}} x_2^2 - x_2^{\frac{4}{3}} x_1^2}.$$

The application of this formula gives the values of α corresponding properly to the mid-point between the two points from which it was derived. They also have a progressive value, indicating that the pole of the corona is not on the plane of the disk. It will not be far wrong to assume that value of α which is nearer the first α than the second, as would be seen by inspection from the points on a sphere.

Now substituting these values of α in

$$N = \frac{8\pi}{3} \frac{x^2 \sec^2\alpha}{(x^2 \sec^2\alpha + y^2)^{\frac{3}{2}}}.$$

we find that the ranging nature of the NS has ceased, and that there remain only such irregularities as are occasioned by the inaccuracy of the measurements themselves.

TABLE III.

S. W. Quadrant.					S. E. Quadrant.				
Ray.	a.	Adopted a.	θ.	Mean θ.	Ray.	a.	Adopted a.	θ.	Mean θ.
1	87° 16′	87°	35° 0′		1	88° 34′	88° 50′	31° 41′	
	87 48		31 41			87 18		33 25	
			30 21	32° 41′				29 28	31° 31′
2	84 16	84	29 22		2	88 27	88 40	30 28	
	82 0		31 23			85 49		32 34	
			30 44	30 30				(22 23)	31 31
3	82 25	82	33 59		3	79 26	79	34 25	
	79 36		32 26			71 53		34 59	
			30 50	32 25				31 48	33 44
4	77 40	78	30 17		4	71 21	71	33 45	
	72 50		31 25			65 10		34 1	
			30 14	30 38				31 38	33 8
5	74 55	75	33 51		5	65 43	66	34 1	
	64 15		35 51			60 40		34 19	
			33 20	34 21				33 25	33 55
6	57 4	59	36 33		6	62 8	62	34 52	
	51 1		36 35			48 6		34 54	
			35 41	36 16				32 38	34 8
7	----	--	----		7	41 54	42	35 8	
	48 51	48	38 59			34 33		35 13	
			38 57	38 58				35 11	35 11
8	33 15	33	41 6		8	40 20	40	39 7	
	23 12		41 7			31 39		39 11	
			40 30	40 54		28 16		38 39	
								37 26	38 18

N. E. Quadrant.					N. W. Quadrant.				
Ray.	a.	Adopted a.	θ.	Mean θ.	Ray.	a.	Adopted a.	θ.	Mean θ.
1	----	--	----	----	1	----	----	33° 5′	
	89° 22′	89°	30° 48′			74° 14′	75°	30 17	
			28 35	29° 42′				30 2	31° 8′
2	89 48	88 50′	----		2	58 50	65	28 2	
	88 53		28 32	28 32		16 3		27 41	
			(19 27)					26 11	27 18
3	85 21	85	28 43		3	73 12	73	36 30	
	81 45		32 55			64 40		34 5	
			30 59	30 52				32 5	34 40
4	81 20	81	31 8		4	67 55	68	34 52	
	74 38		33 39			45 6		33 30	
			30 32	31 45				32 26	33 36
5	74 50	75	32 41		5	59 17	59	34 24	
	69 57		33 17			54 58		35 0	
			31 32	32 50		39 30		34 23	
						28 10		33 5	
6	61 37	64	33 25					31 29	33 37
	68 32		33 18						
			34 34	33 46	6	30 16	30	41 55	
								41 58	
7	48 59	49	36 0					40 49	41 34
	0 58		36 23						
			35 16	35 53					
	20	24	42 25						

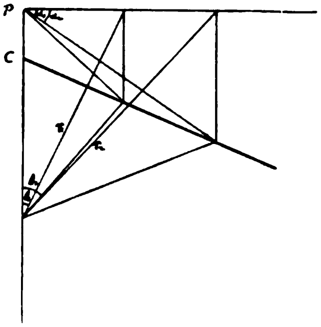
Take the typical formula for N and compute $\sin^2\theta = \frac{3}{8\pi} . \mathrm{N}$. The angle θ derived from this is the distance from the coronal pole at which the observed rays have sprung up from the surface of the sun. The values may be slightly in error by the small inaccuracy of the chosen a, but the changed projection resulting from this imperfection is not great.

This table shows that the coronal rays have their bases in a zone about 34 degrees from the coronal pole, the belt being about ten degrees in width, but its maximum density at the parallel of 34 degrees. The conclusion is drawn that there are no visible rays in the neighborhood of the poles, and hence the appearance of the corona is similar to that of the terrestrial aurora.

Position of the Coronal Poles.

We find the location of the north and south poles of the corona in the following way.

4.



P = projection of coronal pole c on a plane through the poles of the ecliptic.

Let $r_1\,\theta_1$ represent the measured coördinates of each point, with the numerical suffix.

α_1 = angle at pole of disk to the point on the ray.

p_1 = angular distance from pole of disk to point.

θ' = angular distance from coronal pole to point.

r' = radius of spherical surface through point.

B = angle at coronal pole from pole of disk to point.

c = angular distance of coronal pole from pole of disk.

Then $x_1 = r_1 \sin\theta_1$.

$y_1 = r_1 \cos\theta_1$.

$z_1 = x_1 \tan\alpha_1$. $\mathrm{D}_1 = x_1 \sec\alpha_1$.

$$\tan p_1 = \frac{\mathrm{D}_1}{y_1} = \tan\theta_1 \sec\alpha_1.$$

$$r^2 = x_1^2 \sec^2\alpha_1 + y_1^2.$$

$\mathrm{N} = \frac{8\pi}{3} . \frac{\sin^2\theta_0}{r}$, where $r = 1$ for typical N, and θ_0 is the mean angle as computed.

$$\sin^2\theta' = \frac{3r}{8\pi} . \mathrm{N}.$$

In the Spherical Triangle ABC we have given, $a = \theta'$, $b = p_1$, $\mathrm{A} = 90° - \alpha_1$.

Hence, $\sin\mathrm{B} = \sin p_1 \cos\alpha_1 \operatorname{cosec}\theta'$.

$$\tan\tfrac{1}{2}c = \frac{\cos\frac{1}{2}(\mathrm{A}+\mathrm{B})}{\cos\frac{1}{2}(\mathrm{A}-\mathrm{B})} . \tan\tfrac{1}{2}(p_1+\theta').$$

Table IV.

S. W. Quadrant.

Ray.	log r'.	θ'.	p.	A.	B.	c.	Mean c.
1	0·12501	38° 35′	41° 29′	3° 0′	176° 49′	2° 51′ 18″	
2	0·08771	34 9	36 3	6 0	173 42	1 58 4	
3	0·11735	37 51	40 44	8 0	171 29	2 56 34	
4	0·09399	34 36	37 18	12 0	167 11	2 45 20	
5	0·11606	40 10	41 46	15 0	164 30	1 12 16	
6	0·09166	41 6	42 25	31 0	148 6	1 8 56	
7	0·17873	50 45	50 28	42 0	138 13	−0 23 42	
8	0·16308	52 11	52 27	57 0	122 41	0 30 34	1° 44′ 56″

S. E. Quadrant.

Ray.	log r'.	θ'.	p.	A.	B.	c.	Mean c.
1	0·08655	37 17	35 0	1 10	178 47	1 37 56	
2	0·08100	35 6	39 57	1 20	165 8	0 0 0	
3	0·11272	39 13	40 40	11 0	168 48	0 51 38	
4	0·09148	37 24	38 11	19 0	160 39	0 49 34	
5	0·08849	38 10	39 0	24 0	155 32	0 54 26	
6	0·08014	37 59	38 50	28 0	151 25	0 58 48	
7	0·04482	37 21	39 13	48 0	129 15	2 51 32	
8	0·05173	41 8	42 2	50 0	128 47	1 23 50	1 10 58

Mean value of c for the south pole, 1° 27′ 58″.

N. E. Quadrant.

Ray.	log r'.	θ'.	p.	A.	B.	c.	Mean c
1	0·21388	39° 20′	40° 55′	1° 0′	178° 58′	1° 35′ 0″	
2	0·09169	34 45	36 4	5 0	174 50	1 20 14	
3	0·09717	36 3	37 27	9 0	170 42	1 24 30	
4	0·09678	37 19	38 23	15 0	164 38	1 5 16	
5	0·08194	38 41	38 36	26 0	154 3	−0 5 28	
6	0·05725	38 46	39 38	41 0	138 4	1 8 58	
7	0·12036	49 48	50 53	66 0	111 53	2 46 18	1° 9′ 21″

N. W. Quadrant.

Ray.	log r'.	θ'.	p.	A.	B.	c.	Mean c
1	0·09564	35 15	37 33	15 0	164 8	2 24 2	
2	0·05720	29 20	29 11	25 0	155 7	−0 6 38	
3	0·12128	40 52	43 10	17 0	162 12	2 24 30	
4	0·10837	38 49	42 32	22 0	156 10	4 2 34	
5	0·07499	37 3	39 5	31 0	147 28	2 17 1	
6	0·13909	51 9	51 39	60 0	119 18	1 0 32	2 0 20

Mean value of c for the north pole, 1° 34′ 51″.

If θ' is smaller than p, c is positive, and the coronal pole is on the earth side of the plane of the disk.

This table is computed by taking the first point measured on each ray, and selecting the values of r_1 θ_1 from Table II, and a, θ_0 from Table III. As shown by the formula, r' θ' is the computed point whose coördinates of projection were measured; p is the angular distance from the pole on the disk; A and B the interior angles of the triangle at the respective poles, and c the required angular distance of the coronal pole from the disk plane.

Now investigate the heliographic latitude over which these coronal streamers appear to terminate as definite lines. By many computations it is found that the r for the extreme points measured is equivalent to the $\log r' = 0{\cdot}39800$, of lines which leave the sun at polar distance $\theta' = 34°$.

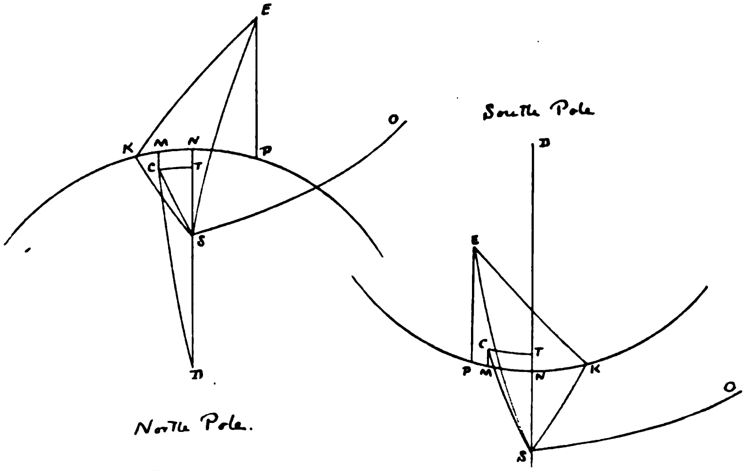
$$N = \frac{8\pi}{3} \cdot \frac{\sin^2\theta}{r}, \text{ where } r = 1 \text{ at the surface; hence } N = 2{\cdot}620.$$

$$\text{Then, } \sin^2\theta = \frac{N \,.\, 3r'}{8\pi}; \text{ and } \theta = 62° \; 10'.$$

The corresponding equatorial distance is $90° - 62° \, 10' = 27° \, 50'$, which is in the midst of the zone of the sun spots at the minimum of the period.

The heliographic latitude and longitude of the north and the south coronal poles, as seen on July 29, 1878, are obtained as follows.

5



Location of the coronal poles for July 29, 1878.

K Poles of the ecliptic.
S Poles of the sun's axis.
E Poles of the plane of the equator.
C Poles of the corona.
D The center of the disk.
KP The plane through the poles of the ecliptic perpendicular to the radius vector to the earth.
M The projection of poles of the corona on the disk.
N " " " sun " "
P " " " equator " "
O The direction of the ascending node at 74° longitude.

The North Pole.

KN Position angle KDS = + 4° 27′·6 counted from N to W.

KP " EDK = −14° 22′·1 " N " E.

PN " EDS = − 9° 54′·5 " N " E.

NM Position angle of coronal pole = −1° 6′ counted from N to E.

MC Angular distance of coronal pole from plane of disk, on the side towards the earth = 1° 34′·8.

PM Position angle of coronal pole = −11° 0′·5 counted N to E.

KS The inclination of the sun's equator = 7° 15′.

NKS = (270° + ⊙)—(270° + 74°) = 126° 10′·97 — 74° = 52° 10′·9.

tan NK = cos NKS tan KS = 8·89212. NK = 4° 27′·6.

sin SN = sin NKS sin KS = 8·99866. SN = 5° 41′·6.

ST = SN − CM = 4° 6′·8. CT = MN cos CM = 1° 5′·97.

cos CS = cos CT cos ST = 9·99880. CS = 4° 15′·4.

cot CST = sin ST cot CT = 0·57257. CST = 14° 58′·8.

NKS = 52° 10′·9. NSK = 38° 2′·6. NSC = 14° 58′·8.

CSK = NSK − NSC = 23° 3′·8. OSK = 90°.

OSC = OSK − CSK = 66° 56′·2. Heliographic longitude.

90—SC = 85° 44′·6. " latitude.

Coördinates of the north coronal pole:

Long. 66° 56′·2
Lat. +85° 44′·6

The South Pole.

KN = KDS = − 4° 27′·6 counted E from S.
KP = EDK = +14° 22′·1 " W " S.
PN = EDS = + 9° 54′·5 " W " S.
PM = EDC = 3° 54′·5 " W " S.
PKS = 52° 10′·9.
KS = 7° 15′.
SN = 5° 41′·6. MN = 6° 0′.
KN = 4° 27′·6. MC = 1° 28′·0.
ST = 7° 9′·7.
cos SC = cos ST cos CT = 9·99420. CT = 5° 59′·88.
SC = 9° 20′·5.
cot CST = sin ST cot CT = 0·07400.
CST = 40° 8′·5.
SKN = 52° 10′·9.
NSK = 38° 2′·6.
CSN = 40° 8′·5.
CSK = 78° 11′·1. OSK = 90.
OSC = 168° 11′·1. Heliographic longitude.
90 − SC = 80° 39′·5. " latitude.
Coördinates of the south coronal pole:

Long.	168° 11′·1	Difference of longitude.
Lat.	− 80° 39′·5	101° 14′·9

It is interesting to compare these coördinates of the polari- tion of the sun with the similar coördinates of the magnet- n of the earth, as given by Erman and Petersen for 1829, om Gauss' Theory.

North Pole,	Long.	266° 3'·8
	Lat.	73° 21'·
South Pole,	Lon.	150° 44'·9
	Lat.	− 72° 40'·4
Difference of Longitude,		115° 18'·9

This fact of general agreement of the difference of longitude ay be purely accidental, or it may point to some fundamental w of polarized rotating spheres.

This analysis of the solar corona suggests certain conclusions.

1. The force seems to be repulsive, the law of its action ing expressed by a transcendental equation of the second gree. This agent is sufficient for the transportation of finely bdivided matter, and harmonizes with the lack of density of e sun's atmosphere, as indicated by its failure to influence the otion of comets passing within its limits.

2. The individual streamers are grouped in a zone about ten grees wide, whose maximum density is at 34 degrees from e coronal poles. The number of such rays is not great, but eir actual dimensions are enormous. The average linear *isible* extension is about one solar radius, and regarding the sidual propulsion and curve of the trajectory their extremities e located normally above the sun spot belts. At this place e incandescence of the material particles apparently ceases, d if condensation sets in, there would exist the conditions quired for the precipitation of cool masses, whose fall pon the surface of the sun is generally supposed to produce e spots. It is at this zone of maximum for the coronal rays at the deficiency of the prominences has been observed, and ere may well be a physical connection between these two lasses of phenomena. The re-entering form of the curves is lso consistent with the existence of atmospheric currents owing from the polar regions towards the equator, and a tudy of the angles of inclination of the prominences relatively normals may develope some evidence on this point. The ondensed bodies of light, seen on two axes at 40 degrees from he poles, are doubtless due to the perspective effects of the aximum zone as it passes around the sides of the sun; and he structureless equatorial wing is no doubt a floating mass f matter, cooling in the process of preparation for precipi- ation. This return of the ejected matter to the sun is consid- red necessary to account for the relation of the total flow of

energy outwards and the rate of change in its volumetric dimensions, as derived from theory.

3. The location of the coronal poles at successive eclipses will afford a means of determining the period of the rotation of the sun on its axis, in consequence of the large number of revolutions occurring between such epochs. It would be necessary to assume that the axis of polarization of the sphere remains the same, as is probably the case.

4. The accelerated angular velocity of the equatorial belts as compared with the polar regions, would result from the descent of cool matter from high altitudes above the surface of the sun, each particle being considered as a satellite approaching its center of gravity. The motion of the spot belts in latitude synchronously with the display of energy as recorded by the maxima and minima, may be due to a corresponding motion of the maximum zone towards and from the poles, with the accompanying elevation of the ends of the coronal stream lines; or to changes in the relative energies of propulsion, as a function of the time. It is possible that a picture of the corona may be sometime taken which will show these streamers distributed in two parallel belts a few degrees apart. It is a most interesting question in physics as to the reason of the location of this coronal zone at the computed distance from the poles, since it suggests also a problem similar to that of the terrestrial auroras. At this place the linear distance across the greatest number of equipotential surfaces, is apparently the shortest, hence it may be the path of least resistance. There should also be a connection between the distribution of the actinic light of the corona and the equipotential surfaces, and it is not unlikely that the light is simply proportional to the potential.

This discussion suggests the importance of securing photographs of the corona sufficiently large to admit of accurate measurements; the necessity of studying the relation between the position of the streamers and the spots at the moment of the eclipse; and the possibility of deriving the period of the sun's axial rotation from the coronas of successive eclipses.

ART. XLV.—*Superimposition of the Drainage in Central Texas;* by RALPH S. TARR.

IN the number of this Journal for last May the writer described the general history of the drainage system of Central Texas as far as it could be read with our present knowledge of the region. In that paper it was shown that the present drainage is superimposed, having originated upon the Cretaceous strata in Tertiary times and, after removing this covering from the buried Paleozoic rocks, finding itself superimposed upon these hard rocks. There is abundant proof of this; for the central Paleozoic region is only partially uncovered and the denudation of the Cretaceous is still in progress. One of the chief effects of the superimposition is that the Colorado river, one of the great arteries of eastern Texas, flows, in its middle course, for many miles over hard Silurian marble containing great quantities of flint. This barrier, accidentally discovered in cutting through the Cretaceous, has retarded the river in its down cutting.

Since writing the former paper two points connected with the drainage of Central Texas, which then puzzled me, have become clear; and as they are interesting confirmations of the superimposition theory for the origin of the present drainage of the region I give them below.

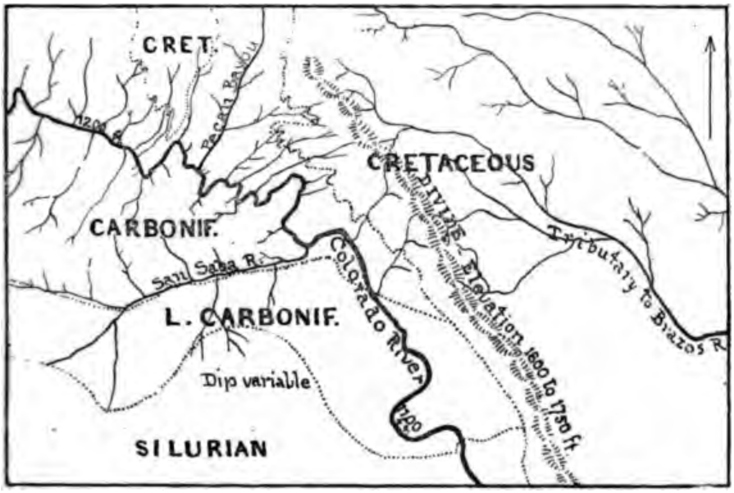
A superimposed river, having selected its course with reference to a structure now no longer present, naturally finds itself flowing without reference to the nature of the newly discovered beds. Thus it is that the Colorado in central Texas is now busy with a barrier of hard Silurian rock, and thus it is that this river flows with a general course at right angles to the strike of the Carboniferous rocks and in an opposite direction to the dip.

Not only the Colorado itself, but all its tributaries flow without especial reference to structural weakness; but the smaller branches take advantage of the structural peculiarities, showing, in many cases, that they are more recent in origin than the time of removal of the Cretaceous. Moreover, some of the medium-sized streams, which in their upper and middle course flow, perhaps on Cretaceous, quite regardless of Carboniferous structure, have nearer their mouth partly readjusted themselves to the new conditions. The number of strike valleys in the lower course of such streams is quite astonishing since it shows to how great an extent drainage is dependent upon structure and how readily, even under great disadvantages, streams will make use of such weaknesses. In the Carboniferous this is particularly noticeable in valleys carved in soft clays and shale. For instance, the Waldrip Division of soft coal-bearing beds, for a distance of more than 30 miles, is marked by a topographic depression. A single stream does not follow this line of weakness continually as would very likely have been the case had the Carboniferous formed an original drainage-surface, but small streams have their head-waters here and larger creeks flow in it for some distance before leaving it to cross the hard underlying limestone.

Everywhere may be seen signs of attempts at rejuvenation, but it was not until lately that I was able to see that the Colorado itself shares this peculiarity. This river flows with a very serpentine course through the Carboniferous, having a length along the boundary of San Saba county of 50 miles, while at the end it is only 30 miles from the first point. In one place it makes a bend six miles long where a cut off would reduce the distance to two miles. Several possible reasons suggest themselves in explanation of this phenomenon which is quite remarkable in a river with a fall of from two to three feet per mile. Since the Colorado is a superimposed river flowing in its present course chiefly by accident, it is possible that before the Quaternary uplift the river may have been sufficiently old, in this part of its valley, to have the serpentine course common to such rivers. Thus the present form of valley may be inherited from that time. Another possible cause is that the slow removal of the Silurian by retarding the down-cutting in this part of the river-channel has induced a temporary old-age condition. That this is the case to a certain degree is abundantly proved by the extensive flood-plains of the Colorado and its side streams; but whether this is a sufficient cause to account for the phenomenon at present under consideration is doubtful. It may be that both these causes have had some effect, but the chief cause is quite different and is to be found in the futile attempt of the Colorado to adjust itself to the new conditions which it has found in its enforced path, probably aided somewhat by the Silurian barrier which has prevented rapid down-cutting.

The evidence of this attempt at readjustment is that all the main bends in the river have one, and generally both, of the long sides of the loop parallel to the strike of the Carboniferous. This is the case in eleven distinct instances, and in one case the river flows northeast for four miles before turning and cutting across the strike to resume its natural course. Above Elliot Creek in Mills county there is a stratum of coarse, thick-bedded sandstone, which has deflected the Colorado river southwest along the strike for a distance of three and one-half miles before it cuts across it; and then the river flows northeast for a mile before resuming its natural direction southeastward.

Another hitherto unexplained phenomenon in connection with the drainage of Central Texas is that the divide between the Brazos and the Colorado rivers is close to the latter, being in places only six miles distant, while it is fully seventy-five miles from the former. All along the entire course the Colorado has almost no drainage area on the east side. The reason for this, so long a puzzle to me, now seems plain—it is the result of accidents, brought about by superposition. The accompanying diagram illustrates this peculiarity of drainage.



It is probable that both the Brazos and the Colorado originated under practically the same conditions, that is, upon the new Cretaceous land elevated above the sea during the great Tertiary mountain uplift. Their course was plainly chosen with reference to conditions appearing on the surface then existing without regard to what lay below. After cutting through the soft, nearly horizontal Cretaceous rocks, the Colorado came upon the buried Paleozoic and encountered not only the Carboniferous for a considerable distance, but also the much harder Silurian with which it has long been struggling. The Brazos, on the other hand, by the accidental choice of a more easterly course avoided these difficulties. To be sure this river in its middle and upper course is superimposed upon the Carboniferous rocks, but the removal of these is a very simple task compared to that the Colorado had imposed upon it. The consequence of this difference between the two rivers is that while the Colorado in Mills county flows at an elevation of 1,200 feet above the sea-level, the Brazos in the same latitude has cut down to within 600 feet of the sea-level in its soft bed.

This fact has given the Brazos a great advantage over its competitor, the Colorado, for drainage territory; and this, in the battle for conquest of headwater drainage area, has enabled the Brazos to push the divide close up to the Colorado in territory, which, under more favorable circumstances, should belong to the latter stream. The side streams of the Brazos having a much lower plane to which it was possible to base level the drainage area than those of the Colorado had were much more powerful agents of erosion; and the result is that a tributary to the Colorado from the east is rarely 10 miles long, while Brazos tributaries, heading in the same divide, flow fully 75 miles before emptying into their mother stream.

ART. XLVI.—*A description of the "Bernardston Series" of Metamorphic Upper Devonian Rocks;* by BEN K. EMERSON.

[Continued from p. 275.]

The position and extension of the basal quartzite was the first clue to the complex stratigraphical arrangement of the series in its eastward continuation. Beginning at the point already described, east of the road to East Mountain (back of "Mrs. Haley's" on the map), with a strike due east, it has bent round to N. 65° E. before it goes under the massive drumlin which lies east of the river, and on its emergence, it is abundantly exposed, with the same strike, along the southern of the two northwest roads mentioned above, especially south of A. G. Chapin's house. Taking the direction of this road across the valley of Dry brook, it can be followed readily, with the same strike and low S.E. dip and physically unchanged, through the chestnut woods N.W. of the end of Purple's blind road, crossing the first north and south road in Northfield, where a loop of the brook crosses the road; and gradually bearing round to the north, it crosses the State line with a strike N. 10° W.

(*b*) *The quartzite conglomerate.*—Back of Mrs. Haley's, on the Fall River road, and just east of the Williams farm, across the valley, ledges of the rock appear, and it outcrops abundantly along the second road running east from the Fall River road (A. G. Chapin's) to its end. Where the road begins it is an obscurely bedded conglomerate of quartz pebbles, in a dark paste containing much slaty material. The conglomerate here toward its base is exactly like the same rock west of the lime-tone on the Williams farm, and I have no doubt that they vere formerly connected across the valley. Higher up, the ock is a pudding stone with rounded quartz pebbles up to .00^{mm} in length, but mostly 20–30^{mm} long; the abundant uartz sand paste, which wraps round them, cleaves into thick ayers coated with muscovite scales and iron rust, so exactly ike the upper quartzite of the Williams farm, especially the onglomerate layer, that it is difficult to avoid the conclusion hat they are also parts of a single stratum. Calculated upon ts average dip of 20° the thickness of the bed is 123 meters, vhich is only a rough approximation.

In the field south of A. G. Chapin's house is an interesting utcrop. The rock is here jointed with almost mathematical ccuracy, into acute rhombs, the joint-planes passing through he quartz pebbles; and the latter are finely compressed, and ndented one by another. The rock here carries garnets 5^{mm} cross. The rock is unchanged across Dry Brook for a long istance to the northeast. when it crosses the last road; but nce over the range (J. M. Picket) at a point where the brook nakes a loop across the road, the pebbles are flattened out into hin disks, resembling the small lenses of quartz common in rystalline rocks, making it almost doubtful if they may not be f secondary origin—a doubt which does not extend to the ange described above. In the woods, southwest of this point, he rock in some beds is in appearance a fine-grained biotite-neiss, with large garnets surrounded by a broad annular coloress space, in which the biotite is wanting; and in following he band farther north, the pebbles grow smaller, and where t crosses the State line it is below a thin-bedded biotitic uartzite, above a muscovitic quartzite; and in some layers he muscovite becomes abundant and wraps around pencils of uartz, so that the rock obtains a rude columnar or ligniform tructure. It has here an apparent thickness of 107 meters.

At the point already mentioned on the grist mill road (J. M. ickett) where the brook makes a short loop across the road, t the south bridge is a fine section in a high bluff, west from he bridge. The conglomerate strikes N. 45° E. and graduates ownward through fifty feet of quartzite into fine micaceous uartzite and this into flat argillite with minute transverse iotites. The whole is well exposed and plainly conformable. ts dip increases from 22° at the south end to 45° at the north nd, where the upper portion of the bed has this high dip, vhile the lower portion runs up on the argillite with the low ip of 20°. It thus folds around and dips away from a great romontory of the argillite; and it is blackened in many places y a remnant of the argillitic material.

Just after crossing the State line into South Vernon it bends sharply to the southwest, recrosses the State line and, at the point where the grist-mill road (J. M. Pickett) crosses the town-line, bends again northwest and swings in a great curve north across Vernon. All this is well exposed just north of the last house before crossing the line (M. Merrills), and the argillite where it is nipped by the sharply bending quartzite is greatly crushed and filled with quartz combs. This boundary crosses the next road north—the old Bernardston-Vernon road—at a small abandoned house (two houses below the school house) where the brook comes nearest the road. Just behind this house in the side of the brook is exposed a most interesting junction of the conglomerate upon the argillite. Commencing at a ruined dam perhaps 15 rods from the house we find typical argillite which changes through a few feet of spangled schist into thin fissile black muscovitic quartzite with some thicker highly crystalline layers, and this graduates into a highly muscovitic very vitreous quartzite, which is at one place a conglomerate of rounded quartz pebbles 2 to 4 in. long. This is where the water falls over a reef 3 to 4 feet high; it is 2 rods below a wooden bridge. Immediately below is a bed of heavy hornblende rock, massive, in places showing a reticulated structure: masses of this rock built into the piers of a wrecked bridge just behind the house show pebbles, and contain also much green mica, often quite coarse and resembling the more gneissoid rock found out over the South Vernon plain to the river and classed by Professor Hitchcock as Bethlehem gneiss. The series strikes N. 55° W. and dips 45° E. The outcrop is continuous and shows a gradual passage through a spangled argillite and fine-grained quartzite into conglomerate, often coarsely garnetiferous, the change being effected within 50 feet and showing no trace of unconformity. Many masses of a thin fissile pyritous magnetite occur here, but the bed could not be found in place.

East of the boundary line just described, across Vernon to the river, the whole area is underlaid by the basal quartzite except where the West Northfield schist series extends across the State line, west of the village of South Vernon; and across the brook it rises in the hill back of S. Titus's, where the road to the lily pond branches from the Brattleboro road. It dips for the most part to the east except east of the lily pond, where a minor fold of considerable size occurs, caused by the sharp bend of the quartzite on the State line, and here the beds dip south. Followed eastward it becomes more and more feldspathic and the muscovite is largely replaced by biotite, forming a completely gneissoid rock. It is here not distinguishable from the feldspathic quartzite occurring east of the West Northfield series and described below.

The Vernon limestone. — On the Lily Pond road above mentioned and just east of E. G. Scott's house occurs a band of limestone. It is a coarse granular limestone, highly crystalline, of light color, containing some garnet, hornblende and green mica. It contains what seem to be distinct traces of corals and crinoids and in everyway closely resembles the Bernardston bed with which I identify it without hesitation. Especially do the weathered surfaces show a peculiar conglomerate-like structure common at Bernardston. Large rounded fragments of a fine grained white limestone are cemented by a coarser and more highly crystalline limestone, the latter in large amount, as if the rock had been brecciated by pressure and then the fragments rounded by percolating waters and re-cemented. This bed is exposed about 30 rods and may have a thickness of as many feet, but its boundaries are not well exposed. Toward the west it graduates on the strike into a calcareous hornblende schist, and above that, to the south, through an actinolitic quartzite into a quartzite abounding in large garnets and blotches of a greenish mica, while below it is succeeded by very coarse hornblende schist in large force. The whole series is enclosed in the gneissoid quartzite.

Description of the range from Bernardston to South Vernon.—Directly opposite the Williams farm and 200 rods distant, on the east side of Fall River, begins a range of low hills, which runs northeast between the two towns named above. This range of hills is backed on the northwest by a much higher range of argillite hills—Bald Mountain, Pond Mountain—and bounded on the southeast by the high terrace sands through which one large area and many smaller islands, of the rocks of the Bernardston series, emerge. I have called this the West Northfield range, from the town in which it for the most part lies. The road running along the east side of Fall River skirts the range at its western end, and the main road from Bernardston to South Vernon borders it on the south and east, while the roads which branch from the latter and cross the range are named from some resident upon each, as given in Beers' atlas, and as marked on the map on page 264.

The mapping of this area was difficult both because the rocks are thrown into great confusion, many beds being in places echeloned, so that the local strike regularly disagreed with the general run of the bands, and because of the presence of several large drumlins which effectually conceal the underlying rock. The intervening areas are, however, so entirely free from drift, up to the very foot of these hills, that, were it not heavily wooded, the region would furnish abundant outcrops, and, as it is, the fragments on the surface can be safely used to determine the rock below. The series wraps round the argillite, and uniformly dips away from it, generally at low angles, at first south, and then for a long distance southeast; then it swings sharply round, crossing the State line with dips a little north of east, making thus a great bend to the westward as it crosses the town of Vernon. I have not been able to prove the existence of folds or overturns, and the present position of the beds seems to be best explained as the result of very extensive faulting.

(*a.*) *The Argillite.*—I have assigned to the argillite the broad area marked "Coos" upon Professor Hitchcock's map, to which he also assigns the slates of the Bernardston series, because I have found that the boundary between it and the argillite to the west, as given upon that map, has no justification in any physical change in the character of the rock where it is drawn, and the argillite can be traced unchanged up to and dipping beneath the quartzite next described. It is true that minute scattered garnets and very small staurolites are found sparingly in the rock in some places in this area, and these seem to have been relied upon by Professor Hitchcock in making the assignment of the rocks to the Coos; but the same garnets can be found at times in the undoubted argillite in West Mountain, and these, and the same minute staurolites, occur in the center of the Whately argillite, and both the minerals are very different from their representatives in the Coos group. Both in macroscopical and microscopical structure, the rock remains quite constant up to the quartzite, and in its finer grain, its darker color, its excessive contortions, and its abundant and large quartz veins, it is well distinguished from the slates of the higher series.

(*c.*) *The mica schist and hornblende beds.*—Resting on the basal quartzite, and dipping from it with low angle to the south, southeast and east successively, as it folds around conformably with it, is a broad area of mica schist, with several bands—probably five—of hornblende rock, and a central band of gneissoid quartzite. From the unequal rigidity of these rocks, they are thrown into great confusion, and from the similarity of the rock in the separate bands, the tracing of them is very difficult, and as they are placed upon the map, a greater regularity appears than exists in the field, many bands being made up of the slightly shifted portions of what was originally one, and many minor faults being of necessity neglected.

In general the schist is, below, finer grained, more slaty, with small development of the transverse mica, without staurolite, and with quite small garnets, becoming, above, coarser, of rougher surface, and knotted with large staurolites.

At the south end, nearest the Williams farm, the basal quartzite dips beneath a very fine-grained flat fissile mica slate, which dips 20° in the direction S. 10° E., its surface sparsely pimpled with small garnets, and without other accessories and closely like the underlying schist of the Williams farm section.

The lowest bed of hornblende rock, here thin and poorly exposed, is followed by a second band of mica slate exactly like the first, which passes with the same dip and strike beneath a massive, dark gray to greenish-black hornblende rock, greatly jointed, and this is exposed in a broad area nearly down to the main road running east from Bernardston, and extending east to the house of S. J. Green, 100 rods west of the locality mentioned by Professor Dana.* It contains a central band of dark limestone at times 30^{cm} thick. The hornblende rock is capped by a thin layer, never more than a meter thick, of a shining, white arenaceous mica schist, with scattered scales of biotite, and a similar layer was found to cap a similar hornblende rock, in so great a number of instances between this point and South Vernon that it attracted particular attention. It was found to pass in every case up into the common dark gray mica schist, and to differ from it only in the entire absence of coaly matter and magnetite; and it seems possible that the former may have been discharged by the ferruginous matter of the hornblendic band adjacent. It is, however, wanting below the hornblende bands which rest directly on the dark gray and finer mica schist. This makes it probable that none of the hornblende bands are overturned.

The schists of the area just described are cut off, going eastward, by a great drumlin, though the quartzite can be followed by the north end of it; beyond one finds sections which expose the whole thickness of the schists and hornblende bands.

They are best studied in the area east of the Purple blind road—see map—where, commencing in the chestnut woods northeast of the end of the road, at the basal conglomerate, we pass south over a broad area of the lowest mica schist, broad because of the low dip, and come upon the lowest hornblende rock, a band—about four meters thick—here, as always quite ferruginous and pyritous. Fifteen meters beyond there is a second bed of hornblende rock like the first, and both are capped by the white mica schist layer described above. Going on twenty meters to the top of the ridge, at a large chestnut tree conspicuous in the open field, there is a third rudely laminated layer of hornblende rock, thicker than the others and distinctly laminated. This is capped by a bed one meter thick, of a very rusty limestone, carrying abundantly light colored garnet, in large shapeless masses, and light green pyroxene. A long slope follows with scanty outcrops of mica schist, still fine-grained and without staurolite, but with no trace of hornblende; and, at its foot, succeeds a heavy bed of hornblendic rock about twenty meters thick, which by the quite abundant development of feldspar is in large part a complete *quartz-diorite.* Except for the appearance of feldspar, in small irregular white spots, it does not deviate from the usual type of the hornblendic rock of the area. It is followed almost immediately, though the exact contact could not be found, by a bed about fifteen meters thick, of a fine-grained granitoid quartzite, which is indeed, in its whole extent, a *complete granitoid gneiss*, never fissile, and faintly laminated only by the parallel arrangement of the biotite, or wholly lacking this even, and becoming a fine-grained tough *granite, largely feldspathic*, and with many streaked cleavage surfaces, and light gray from the small amount of the biotite. It can be followed here for a long distance, breaking off against a fault in the northeast direction, and going southwest, across Dry brook. Its place between the two heavy hornblende bands seems to be taken by a very fine-grained massive quartz rock, with abundant fine scales of muscovite, and with large round plates of biotite set at every angle. It appears again farther northeast at the last road across the range, and can be followed thence continuously, over the high hill west of South Vernon station and across the plain in Vernon, trending here directly toward the point where the road to Vernon goes beneath the railroad. It is unlike the quartz-conglomerate on the west, and feldspathic quartzite to be described on the east; and conforming in dip and strike with the mica schist, and making all the curves with it, it must be looked upon as a separate band in the mica schist, and cannot well be derived by folding or faulting from the other quartzite.

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* This Journal, III, vi, 342, 1873.

On the section line it is separated by a small thickness of mica schist from another heavy hornblendic bed, which latter is itself parted by a thin layer of schist, and separated by a heavy bed (30 meters) of a dark gray mica schist, much coarser than the beds below, and carrying abundantly transversely placed biotite, small garnets, and large staurolite crystals, the latter in single crystals, and in twins according to both the common laws. This greater coarseness of the texture, and the great abundance of staurolite in the upper beds of the mica schist, are the rule through the whole length of the range, and militates against any attempt to make out repetitions in the series now gone over. This band is capped by another heavy bed of hornblende rock 20–25 meters thick, which rises in a ominent ridge overlooking an isolated house (W. Soudin's), d is followed by one more repetition of mica schist, before ming to a fault, upon a broad area of feldspathic quartzite to be described later—which continues to the railroad at the rthwest corner of Gill; and if the section is continued oss Grass Hill to the Connecticut river, it cuts first a broad ntinuation of this upper quartzite, followed by a complete petition of the mica-schist series, with five hornblendic bands, e feldspathic, and the eastern sloping down the hillside om the Moody school buildings to the river, and thus cover-g a large area.

Sections carried across the area anywhere from the quartzite se southeastward, give substantially the same succession as at detailed above, only for a distance east of the line there osen, there is a fault and a repetition of the beds; so that arting from the same point as the one chosen for the begin-ng of that line, and going directly east, to the saw-mill, on e South Vernon road, nine distinct hornblendic bands are assed, and in almost every case each band is found capped by e whitish schist described above. Also along the State line, d for a distance north and south; either by the thinning of e beds of mica schist or by the slipping of the hornblendic ands over them, the latter are unusually approximated, the ree bands below the middle quartzite coming into close prox-nity to each other, and with the basal quartzite; it is sepa-ted by a broad mica-schist valley from a prominent horn-lende-rock ridge, just in the east edge of the woods looking own on South Vernon, which is subdivided by only very thin yers of schist. Still farther east, in the large pasture above e South Vernon Hotel, the beds are greatly faulted as indi-ted upon the map. It illustrates the abundant faulting of e region that at the two short railroad cuts in these beds ere are in each case two marked faults, bringing quite distant eds into contact.

Just south of the South Vernon station nearly horizontal ica schist is faulted, on the north, against a dike like mass of ornblende rock, about 10 meters wide; and on the south, an qually distinct east-west fault-line separates the latter rock om the feldspathic quartzite, also nearly horizontal.

At the next cutting, three miles farther north, near where e road crosses the railroad, one band of the hornblende rock is ushed over another and the quartzite over both, so that they ave a common dip of 25° S. 65° E.; but the fault planes are istinctly visible, and both the hornblende rock bands are capped y the whitish schist layer which marks their transition into e common mica schist.

The type of the hornblende rock, as seen in the area described above, and in many bands stretching across the country to South Vernon, a type from which there is little variation, is a dark gray to black, fine grained, wholly massive rock, *resembling* so exactly, especially in its jointing, *an intrusive diorite*, that it was connected with the Mesozoic diabase in the first work of President Hitchcock, and the occurrence of it faulted between mica schist and quartzite at the South Vernon station, was called trap, by so experienced an observer as Professor C. H. Hitchcock in his latest work on the area.* The hornblende is generally arranged in fibrous radiated tufts, just visible with the lens, which aids in giving the rock its great toughness. It is not prone to weathering, and stands up generally in long ridges, the schists having been considerably lowered on either side of it, but at the railroad cutting in South Vernon, its fissures were coated with an abundant deposit of calcite and pyrite.

Because of its position in the hollows between the hornblende ridges, the mica-schist, which really occupies much more of the surface than the former, seems, on casual inspection, to be of subordinate extent and importance.

The thickness of the beds, calculated on the average dip of 22° is, quartzite 107 meters, mica schist 113 meters, hornblende rock 158 meters; which is certainly far too large judging from the long line of outcrops farther northeast, and it is probable that each is partially repeated several times by cross faults.

I have elsewhere suggested that hornblende bands of this type are generally derived from limestone beds, and in fact the hornblende bands are still locally quite rich in carbonates, as at the locality first described above just east of Fall River, the broad hornblende band contains layers of limestone 20–30$^{\mathrm{mm}}$ thick; and farther northeast, at a large chestnut tree east of the end of the Purple blind road, there occurs in the same association a bed nearly a meter thick of impure limestone carrying garnet and pyroxene.

The development of hornblende at the upper surface of the crinoidal bed has been detailed above, and the large development of hornblende in the quartzite in South Vernon points in the same direction. The hornblende derived from calcite has always a very low absorption.

The feldspathic Quartzite.—Reserving the question of the identity of this rock with the basal conglomerate, I may first call attention to its curious distribution on the map. It occupies a broad area along the eastern border of the schist series, dips everywhere away from it to the eastward with apparent conformity, makes the same folds with it all the way from the State-line, south to the point where the main South Vernon-Bernardston road crosses the railroad, even swinging round to a N.–S. strike where the schists do. Beyond this point it occupies a broad area stretching from the railroad across to the Purple blind road, and is plainly separated from the schists on the north by a curvilinear fault. Thence it continues in a broad band southeastwardly, a long distance, and can be followed in scattered outcrops across the sand plains into the town of Gill. Beyond Dry Brook it seems to regain its conformity with the schists. Across the narrow neck by which the West Northfield sands join those of Bernardston, the same quartzite reappears in the northwest shoulder of Grass Hill, and is apparently continuous under the sands with the larger area west of the railroad. It dips under the hornblende rock to the east.

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* Geol. N. H., ii, 438.

It is everywhere a fine grained light gray fissile quartzite, with small fresh feldspar crystals porphyritically disseminated in it, often quite abundantly. These reach 1–2^{mm} in cross-section, are often but not always striated. They are much larger than the quartz grains and have often sharp crystalline outlines.

In the area south of the great fault at the Purple blind road, and far west from here, it is marked by the abundance of the grains of lavender quartz included in it, which appear to have come from the Archæan gneiss of the Green Mountains. Muscovite, so abundant in the lower quartzite, is wholly wanting; rarely a small amount of biotite in fine scales, or, at one outcrop, of hornblende in scattered needles appear.

The dips of the rocks and of the slates below are so low, and, with the strike, vary so rapidly and irregularly within narrow limits, that I am left in slight doubt as to the exact conformity of the two for any long distance. Going north or south from the northern road over the range, along the line of junction for two miles, no contact of the two could be found, but in the whole distance they seem exactly conformable, and to have shared all minor disturbances together; for instance, although the rocks are tilted so that they strike N. 65° E. and dip 40° S.E., they have also been subjected to an E.–W. thrust, as is seen on a large scale farther south, so that small portions placed irregularly among the rest have a N.–S. strike, which is shared by both the schists and the quartzite.

The basal conglomerate often blackened by argillitic material is a rock of very different habit from this fine grained biotitic feldspathic quartzite; but the description above given of the passage of the beds across Vernon indicates that the former passes into the other going eastward beneath the schists and is then brought up by a fault along the eastern base of the schist series, and in places thrust over the latter in apparent conformity. The fault line must be an exceedingly tortuous one, and on the east the Grass Hill series must be a repetition of the West Northfield series.

The Bernardston Series east of the Connecticut.—The adjoining area east of the river in Northfield, is unfortunately so covered by the terrace sands, that only few outcrops appear. I think that the rocks of the Bernardston series find their eastern limit through the whole length of Northfield, Ewing and Montague, at the foot of the high ground which bounds the Connecticut Valley on the east; that it ends without any marked shore deposit; but with great crushing of the fine quartzite, probably on a fault of great magnitude and extent, and finally that the quartzite schists and amphibolite, which succeed to the east in the Northfield Hills, though presenting some points of similarity with the Bernardston rocks, are to be associated rather with the series which lies west of the argillite and which are presumably older.

The Quartzite in Northfield.—North of this village, a porphyritic quartzite identical with the eastern band in the West Northfield range, crops out along the eastern edge of the high terrace, but is immediately followed on the east by an older series mentioned above. It is much brecciated and abundantly cemented by hematite. It appears also in the brook bottoms; and just over the line in Winchester, a shaft has been sunk a hundred feet in it for lead, which appears very sparingly in narrow interrupted fissures of a few millimeters width, associated with barite and fluorite in equally small quantities, and at the bottom with beautiful druses of pale yellow, saddle-shaped, dolomite crystals. Below the surface the quartzite is snow-white, but otherwise unchanged. The rock is a hard white saccharoidal sandstone, regularly porphyritic with small clear feldspars in stout rectangular cross sections for the most part striated, and plainly of secondary growth since they enclose sand grains. It is here everywhere massive. Outcrops are seen in all brook beds in the north part of the town, and it approaches nearest to the older series, in a lane running east from the Moody homestead and along the Winchester road. It is here greatly brecciated and full of quartz and hematite veins. On the east of the boundary line several bands of the older series abut obliquely against this line, so that the quartzite on the west rests in manifest discordance, either due to unconformability or faulting against the older series.

The Mica Schist east of the Connecticut River in Northfield.—East of the river only a single limited outcrop of mica schist occurs, a half mile below the village, just opposite Grass

Hill, and 200 rods from the nearest outcrop of hornblende rock, on the west side of the river. It agrees in texture with the lowest beds of schist on the west of the Connecticut, is fine grained, and carries few accessions. It abounds in flattened cavities, which seem to be the obscure traces of fossil shells, but they are wholly indeterminable, if indeed they be of organic origin at all. Upon the joint faces are abundant weathered crystals of a flesh colored zeolite, apparently chabazite. The exact locality is by the brook crossing, at a mill pond near A. Billings'.

Conclusion.

The section below seems to me to represent the succession of the beds represented, the newest above.

1. Mica schist,
2. Hornblende schist,
3. Mica schist,
4. Hornblende schist,
5. Mica schist,
6. Hornblende schist,
7. Mica schist,
8. Quartzite,
9. Hornblende schist and Magnetite,
10. Limestone,
11. Hornblende schist,
12. Quartzite conglomerate,
13. Argillite,
14. Calciferous mica schist.

Originally heavy beds of shale (*a*) graduated upward into a great series of feldspathic sandstones (*b*) and conglomerates, which contained a band of crinoidal limestone with a local development of iron ore near its surface. Above this was an extensive series of shales (*c*) with several intercalated beds of impure limestone. The first series has changed into a crumpled and cleaved phyllite to which the name argillite has been for a long time appropriated. The second series has passed through all the changes to a gneiss so complete that Professor Hitchcock insists on associating it with the Bethlehem gneiss—quartzite with flattened pebbles, muscovite quartzite, biotite quartzite, feldspathic quartzite often porphyritic, and complete biotite gneiss often becoming chloritic from superficial change.

The limestone has become most coarsely crystalline and the lime and iron have been carried far out into the quartzites above and below to form hornblende schists and complex hornblende-chlorite pyrite rocks.

The iron ore forms a bed of magnetite or a magnetite rock.

The upper series is changed to complete mica-schists spangled with transverse biotite crystals, often loaded with garnets and staurolites; while the limestone beds are changed from the surface toward the center into hornblende schist beds abstracting the iron from an adjacent band of the shales.

The dips are all to the east and the beds are several times repeated by monoclinal faulting and with each reappearance of the quartzite it is finer grained and more feldspathic.

The whole series has a slight pitch to the south, so that in Vernon the whole upper series tapers northward and disappears; and then in going eastward from the argillite we pass from the more quartzose conglomerates through muscovite and biotite quartzites to complete gneisses, as in the successive reappearances farther south.

The most abundant and characteristic fossils are Chemung with several Hamilton forms, so that the limestone, magnetite, and the base of the quartzite above the limestone may be placed with certainty near the base of the Chemung. That the whole series must go together is, I think, clear from the map and the preceding discussion. The suggestion of Professor Hitchcock, that the limestone was bounded on both sides by faults* prove true for the west side, but is not true for the east side, and the important deduction made by him that the limestone was greatly newer than all the surrounding rocks is also disproved.

The argillite, though the oldest rock, is least decomposed, crumpled and cleaved with dull surfaces and full of coal grains and kaolin, in its most eastern exposures showing minute pustules on its slaty surfaces, and at last developing garnet and biotite in some abundance. In the western exposures of the mica-schist series, kaolin could scarcely be detected, and biotite, garnet and staurolite were quite abundant, but almost microscopic, while farther east the surfaces show clearly the muscovite sheen, and the above accessions are abundant and large. In the calciferous mica schist which lies below the argillite the separate muscovite scales are clearly visible to the eye, and the same accessories occur still larger and with a very different and much more complex structure.†

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* 15, p. 315.

† The note in the former part of this paper at the foot of page 264 should be transferred to page 266. It applies to figure 2.

XLVII.—*Analysis of Rhodochrosite from Franklin Furnace, New Jersey;* by P. E. Browning.

HE specimen of rhodochrosite, an analysis of which is here n, was collected for the Yale Museum some two or three s since and was furnished to writer for examination by Pro- or E. S. Dana. It has a massive, cleavable structure and a ht pink color. Franklinite and willemite are immediately ciated with it. The method of analysis was, as follows:

portion of the mineral was dissolved in hydrochloric acid, porated to dryness to separate any silica present. The ate from silica was treated either with sodic acetate or nonium hydrate and the iron separated and weighed. After separation of the iron, the zinc was precipitated as sulphide hydrogen sulphide in acetic acid solution. The filtrate n sulphide of zinc was treated with bromine water, by ch method the manganese comes down as black oxide. In determinations ammonia was used with the bromine water ring about the same result. In all these cases the black de was dissolved and reprecipitated to avoid any holding k of lime. The black oxide in every case was dissolved by hurous and hydrochloric acids, precipitated as phosphate weighed after ignition as pyrophosphate according to bs's method. The amount of manganese being large, two ct determinations were also made by Ford's method, which sists in boiling the mineral, after separating the silica, with ng nitric acid and potassium chlorate until green fumes se to be given off. The black oxide is thus directly pre- tated and may be treated as above by Gibbs's method. se results were satisfactory in their agreement. The filtrate n black oxide of manganese was evaporated to about 300 400cm^3, made ammoniacal, and calcium precipitated as late, dissolved and reprecipitated in same manner. The ate from both oxalate precipitations was evaporated (and two cases the residue was ignited to free it from great ess of salts of ammonia) and precipitated as phosphate, dis- ed in hydrochloric acid, and reprecipitated in same manner h ammonia and a little hydrodisodic phosphate, ignited and ghed as pyrophosphate. Each element was determined at t three times. Five determinations of manganese were de. Two analyses of the mineral were carried through in tinum dishes to avoid any contamination by silica in glass porcelain. The amount of iron in ferrous condition was ermined by dissolving a portion of mineral in sulphuric acid and titrating with a standard solution of potassium permanganate. Three determinations of carbon dioxide were made taking 0·5 gram portions, and a fourth in which 2 grams were used agreed closely with the others. In these determinations the carbon dioxide was set free in suitable apparatus by the action of hydrochloric acid and heating, and weighed after absorption in potassium hydrate. The analysis is as follows:

Specific gravity = 3·47.

MnO	45·02 per cent.
CaO	11·28
ZnO	2·32
MgO	1·76
FeO	0·22
Fe_2O_3	0·16
SiO_2	0·32
CO_2	38·94
	100·02 per cent.

The presence of silica suggested the possible presence of zinc silicate (Zn_2SiO_4) as impurity; accordingly there was deducted from the ZnO found enough to balance the silica, and the remaining constituents were calculated to one hundred per cent. The result is given in I below.

	I.		II.
MnO	45·55 per cent.	$MnCO_3$	73·78 per cent.
CaO	11·41	$CaCO_3$	20·37
ZnO	1·48	$ZnCO_3$	2·28
MgO	1·78	$MgCO_3$	3·74
FeO	0·22	$FeCO_3$	0·35
Fe_2O_3	0·16	Fe_2O_3	0·16
CO_2	39·40		100·68
	100·00		

The hypothetical composition of the mineral, calculating the bases as carbonates, is given under II above. It will be seen that the amount of acid (CO_2) required to supply the bases exceeds the amount found by 0·68 per cent. The ratio of Mn : Ca : Mg = 6·4 : 2 : ·44.

In concluding this paper, the writer would express his appreciation of the valuable advice obtained from Professor Gooch during the progress of the analysis.

Kent Laboratory, Yale University, July, 1890.

ART. XLVIII.—*A Re-determination of the Atomic Weight of Cadmium;* by EDW. A. PARTRIDGE, M.A., B.S.

THE atomic weight of cadmium has been determined by Stromeyer, Von Hauer,* Lenssen,† Dumas‡ and Huntingdon.§ With $O=16$ for the basis of calculation the values obtained by these experimenters are the following: by Stromeyer 111·48, by Von Hauer 111·96, by Lenssen 112·08, by Dumas 112·25, by Huntington 112·24. From these results Clarke calculates 112·092 to be the most probable figure, and concludes his article on the subject with this remark: "It will be seen that Dumas's and Huntingdon's determinations both made with haloid salts of cadmium agree with wonderful closeness and so confirm each other. On the other hand, Von Hauer's data give a value which is much lower. Apparently Von Hauer's method was good, and the reason for the discrepancy remains to be discovered. Until that is ascertained, I prefer to use the above mean value rather than to adopt one investigation and reject the others."

This investigation was undertaken with the hope of arriving at a value for the atomic weight of cadmium more reliable than that given by former experimenters.

The following points were regarded as of first importance:

1st. The most scrupulous care in the purification of the materials used in every stage of the work.

2d. Avoidance of any method in which the reactions involved were uncertain or doubtful.

3d. The utmost care and refinement in weighing.

4th. Use of a large number of determinations as the basis of calculation.

At the outset much time was devoted to making a pure cadmium salt by recrystallization of the sulphate, and much work was devoted to accumulating a stock of this as the starting point. This, however, was discarded in favor of the metal obtained by distillation.

The literature upon this subject is interesting, though somewhat meager. Mercury has been purified by distillation for years. Demarçay‖ in 1882 observed that zinc and cadmium are volatile in vacuo at comparatively low temperature, and suggests this as a means of purification. In 1884, Schuller¶

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* Jour. für Prakt. Chemie, xxii, 350.

† Ibid., lxxix, 281.

‡ Ann. Chem. Pharm., lxiii, 27.

§ Proc. Amer. Acad., 1881.

‖ Comptes Rendus, xcv, 183.

¶ Ann. d. Phys., xviii, 320, and Jahresbericht 1884, 1550.

stated that zinc and cadmium can be distilled in vacuo, leaving the impurities as a residue. This method has been employed by Morse and Burton* for the purification of zinc. One of the means employed by Stas in his classical investigation upon atomic weights was the purification of silver by distillation. Whenever available, distillation ranks first among the processes for purification at the disposal of the chemist. This was affected in the case of cadmium in tube retorts of glass, about 30^{cm} in length and 20–25^{mm} in diameter.

The tubes were closed at one end and drawn down at a point about 11^{cm} from the closed end, making a neck about 12^{mm} in diameter. 100 grams of cadmium having been introduced, the open end was drawn down to a size suitable for a connection with the mercury pump. The portion of the tube between the neck and the end connected with the pump serves to condense and retain the distilled metal.

After having been supported on a combustion furnace, the retort was exhausted as completely as a rapidly acting three-fall mercury pump would effect in one hour. The gauge, then standing only a fraction of a mm. lower than the barometer. As the pump was self-acting this degree of exhaustion was readily maintained during the entire operation. Heat was then slowly applied and so managed that the greater part of the metal condensed and ran down the sides of the retort, only the more volatile portion passing beyond the neck of the tube. A fractional distillation was thus effected, cadmium alone passing over. In an hour 60 grams of cadmium had collected in the receiver, the distillation was then stopped and when entirely cold the metal was removed by cutting open the tube. The greater part of it collected as a bar at the bottom of the receiver, while the sides and top were lined with crystals, many of which were quite perfect. The residue in the retort was covered with a brownish black scum, which was tested spectroscopically and found to consist mainly of lead, iron and thallium, with a little copper. The lines of zinc were once very faintly seen.

The cadmium thus purified was distilled a second time in the same manner. The residue from this distillation, which was pushed no further than the first, remained perfectly bright to the end and when tested with the spectroscope did not reveal a trace of foreign metals. All the cadmium used in this investigation was thus purified by double distillation.

One of the methods used for the determination of the atomic weight of cadmium is that of Lenssen which, although good, was merely touched upon by him. His result was based upon only three experiments, using very small quantities of material

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* Amer. Chem. Jour., x, 311.

The method consists in changing cadmium oxalate to cadmium oxide, and observing the loss of weight from which loss the atomic weight is calculated.

For working this method cadmium oxalate was made as follows:

The perfectly pure metallic cadmium obtained by double distillation was dissolved in pure nitric acid, prepared by careful distillation, and the solution concentrated so far that on cooling the cadmium nitrate $Cd(NO_3)_2+4H_2O$, separated in long fibrous crystals. The latter were drained at the filter pump, dissolved in water, and a solution of the theoretical amount of pure oxalic acid added. Cadmium oxalate thus prepared is a heavy crystalline precipitate which can be easily washed. This was done several times by decantation. The precipitate was then placed on a filter and washed at the pump thirty times with distilled water, after which it was dried for 10 hours at 150° C. The salt thus obtained was tested for nitric acid by the phenol test and showed not the slightest trace. The pure cadmium oxalate thus obtained was subjected to the following treatment:

About one gram of cadmium oxalate was placed in a porcelain crucible and was then dried in an air bath at 150° C. for five hours. This length of time was usually sufficient to dry the salt completely. When this had been accomplished, i. e., when a constant weight had been attained, the crucible containing the oxalate was covered with a watch glass and very cautiously heated. This operation required the greatest care, since if the temperature became too high, reduction and consequent volatilization of metal occurred. Four of the earlier experiments wère lost in this way. That volatilization of metal had taken place was made evident by a slight sublimate on the watch glass. When the oxalate was completely decomposed (this was shown by the uniform brown color of the resulting cadmium oxide) it was allowed to cool and moistened with a few drops of nitric acid in order to re-oxidize any reduced metal. The nitric acid employed for this purpose was especially purified by very careful distillation. Ten c. c. of it evaporated in a platinum dish left a visible but imponderable residue.

The crucible was then very carefully ignited until all the cadmium nitrate was decomposed, then placed inside a nickel crucible 4^{cm} high by 4^{cm} wide and strongly ignited for half an hour by means of a Fletcher's improved Bunsen burner. In all cases the ignition was repeated until a constant weight was obtained. There was rarely, however, any loss of weight after the first ignition. To prevent the possibility of any reducing gases reaching the cadmium oxide, the nickel crucible inside which the porcelain crucible was placed, was forced into a circular hole cut in a piece of asbestos board 13^{cm} square. The top of the nickel crucible was flush with the upper surface of the board, the joint being air tight.

Ten experiments made by the above method gave the following results:

SERIES I.

	Weight of cadmium oxalate taken.	Weight of cadmium oxide found.	Atomic weight.
1	1·09898	·70299	111·819
2	1·21548	·77746	111·793
3	1·10711	·70807	111·755
4	1·17948	·75440	111·780
5	1·16066	·74237	111·783
6	1·17995	·75471	111·784
7	1·34227	·85864	111·829
8	1·43154	·91573	111·823
9	1·53510	·98197	111·821
10	1·41311	·90397	111·834
Total	12·66368	8·10027	(111·8027)

Mean value	111·8027
Maximum,	111·834
Minimum	111·759
Difference	·075
Probable error	·010

Another method used for the determination of the atomic weight of cadmium is that of Von Hauer. It consists in reducing cadmium sulphate to cadmium sulphide in a stream of hydrogen sulphide and observing the loss of weight. As the result obtained by Von Hauer is considerably lower than those obtained by other experimenters, doubt has been cast upon its accuracy. The following possibilities have been suggested as tending to make Von Hauer's results low: 1st. That the cadmium sulphate as weighed by him contained hygroscopic moisture. 2d. That the presence of metallic iron in the ferrous sulphide used in making the hydrogen sulphide would lead to the generation of hydrogen and consequent reduction and volatilization of cadmium. 3d. That some cadmium sulphide might have been volatilized in the stream of hot hydrogen sulphide.

It was, therefore, determined to carry out a series of experiments by this method in order to determine if any of these objections were well grounded.

In the experiments about to be described, the first danger was overcome by weighing the sulphate in stoppered glass tubes. The second was shown to be groundless, as in some experiments the hydrogen sulphide used was prepared from antimony trisulphide and in others from ferrous sulphide with perfect agreement of results. The third objection was disproved experimentally, as the highest heat that hard Bohemian glass will withstand did not cause any volatilization of cadmium sulphide. That there was no volatilization of sulphide was proved by the weight of a sample of the same which was heated in a stream of hydrogen sulphide to the extent just mentioned, remaining absolutely constant, and also by the fact that there was not the slightest sublimate on the tube.

The hydrogen sulphide employed in this and in the following series of experiments was washed by passing it through water and dried by passing through a long calcium chloride tube. The carbon dioxide was dried by passing through a wash bottle containing sulphuric acid and then over calcium chloride By means of a three-way cock the carbon dioxide could be run into the apparatus without changing the connections.

The cadmium sulphate was prepared in the following manner: Cadmium nitrate, prepared as above described, was dissolved in water and a slight excess of pure sulphuric acid added. Five c. c. of this acid were evaporated in a platinum dish, leaving a visible but imponderable residue.

The solution was evaporated to dryness in a platinum dish and heated long after fumes of sulphuric acid ceased to come off. The sulphate was dissolved in water, recrystallized and dried for six hours at 200° C.

The following is a description in detail of the method used in the experiments, the results of which are tabulated below. (Series II.)

The dry cadmium sulphate was placed in a porcelain boat and heated for some time in an air bath to about 300° C. While still warm the boat was placed in the weighing tube, allowed to cool and weighed. Cadmium sulphate parts with its hygroscopic moisture very readily at 300° C. After weighing, the boat containing the cadmium sulphate was placed in a hard glass tube, 50^{cm} in length, supported over a small combustion furnace. A stream of pure dry hydrogen sulphide was then passed through the tube and heat applied. It was heated moderately for 45 minutes and to dull redness for as much longer. By this time its reduction to sulphide was always complete. It was then allowed to cool to about 200° C. in a slow stream of the gas. When the temperature had fallen to this degree the hydrogen sulphide was displaced by a stream of pure dry carbon dioxide, and while still warm the boat containing the cadmium sulphide was placed in the weighing tube,

allowed to cool and weighed. Ten experiments by this method gave the following results:

SERIES II.

	Weight of cadmium sulphate taken.	Weight of cadmium sulphide found.	Atomic weight.
1	1·60514	1·11076	111·793
2	1·55831	1·07834	111·789
3	1·67190	1·15669	111·790
4	1·66976	1·15554	111·818
5	1·40821	·97450	111·801
6	1·56290	1·08156	111·806
7	1·63278	1·12985	111·778
8	1·58270	1·09524	111·797
9	1·53873	1·06481	111·796
10	1·70462	1·17962	111·801
Total	15·93505	11·62717	(111·7969)

Mean value	111·7969
Maximum	111·818
Minimum	111·778
Difference	·040
Probable error	·008

In the course of the work the experiment of passing hydrogen sulphide over gently heated cadmium oxalate was tried. This salt was completely transformed into the sulphide at a temperature much below that which is necessary for its conversion into cadmium oxide. This reaction was then made the basis of a new method for the determination of the atomic weight of cadmium. The method used in the ten experiments, the results of which are given below (Series III), was as follows:

Cadmium oxalate was placed in a porcelain boat and dried at 150° C. to a constant weight. It loses all of its moisture at that temperature. While warm the boat was placed in the weighing tube, allowed to cool and weighed. The boat containing the cadmium oxalate was then placed in a tube arranged for passing hydrogen sulphide and supported over a combustion furnace as above described. The reducing gas was passed through the tube and heat slowly applied. When the contents of the boat had been completely changed to sulphide, the heat was raised to incipient redness and kept at that temperature for about one hour. The cadmium sulphide was allowed to cool to about 200° C. in a slow stream of hydrogen sulphide which was then displaced by a stream of pure dry carbon dioxide. While still warm the boat containing the cadmium sulphide was placed in the weighing tube, allowed to cool and weighed. In every case the sulphide was reheated in the stream of hydrogen sulphide. There was never any volatilization of cadmium sulphide, as the weight always remained the same, although in some experiments the sulphide was heated three times as long as in others. Moreover there was never any sign of volatilization either on the boat or on the tube. Ten experiments by the above method gave the following results:

SERIES III.

	Weight of cadmium oxalate taken.	Weight of cadmium sulphide found.	Atomic weight.
1	1·57092	1·13065	111·812
2	1·73654	1·24979	111·786
3	2·19276	1·57825	111·824
4	1·24337	·89492	111·823
5	1·18743	·85463	111·807
6	1·54038	1·10858	111·771
7	1·38905	·99974	111·806
8	2·03562	1·45617	111·833
9	2·03781	1·46658	111·774
10	1·91840	1·38075	111·814
Total	16·85228	12·12906	(111·8050)

Mean value	111·805
Maximum	111·833
Minimum	111·771
Difference	·062
Probable error	·009

The mean of the three series gives 111·8015 as the atomic weight of cadmium, with O = 16.

The following is a description of the methods and apparatus used in the weighings: In the experiments by Lenssen's method two crucibles were used, one as a counterpoise. This dummy was treated in every respect in the same manner as the crucible containing the material operated upon. For weighing the crucibles, small beakers, with glass covers ground on, were provided. These beakers were adjusted so that their weights were approximately equal. The balance being provided with two riders, one of them was used to obtain adjustment with the beakers on the pans, while the other was used in the actual weighing after the crucibles were introduced. The beakers were never touched with the hands, but were taken in and out of the balance case by means of tongs, and the crucibles were introduced into the beakers with platinum forceps. The adjustment of the balance with the beakers on the pans was tested before and after every weighing, and during the entire series of experiments the greatest variation was ·0001 grams.

For weighing the boats used in the second and third series of experiments, light glass tubes, with accurately fitting stoppers of glass, were made. Two boats were used in every experiment, one as a counterpoise. The boats, while still warm, were placed in the tubes and the tubes stoppered. When quite cold the stoppers were momentarily loosened to restore the atmospheric equilibrium inside the tubes.

The balance used was most accurate and highly sensitive, of the short arm pattern, with an aluminium beam. With a load of 30 grams in each pan the resting point was displaced two whole divisions by ·0001 grams. The weights were adjusted with the utmost care, especially for this work. The weighings in all experiments were reduced to the vacuum standard.

University of Pennsylvania.

ART. XLIX.—*On the occurrence of Nitrogen in Uraninite and on the composition of Uraninite in general. Condensed from a forthcoming Bulletin of the U. S. Geological Survey;* by W. F. HILLEBRAND.

THE following pages contain in much condensed form the results of chemical work thus far done by myself on uraninite from various localities in North America and Europe, of which brief notices have already from time to time appeared.[*] For various reasons it has been impossible to bring the investigation as far forward as was expected, and the results are in some respects incomplete and in others difficult of interpretation, but so much time has elapsed since the work was begun that it seems advisable to make public now what has been achieved, without waiting an indefinite and probably long time for the sake of then presenting the subject in a more finished and satisfactory form.

At an early stage of the work it was found that to the North American varieties could by no possibility be applied the formula obtained by Comstock[†] for the Branchville Conn., mineral, and by Blomstrand[‡] for the Norwegian and Bohemian varieties. Comstock's analysis was shown to be incorrect, he having found no thoria where about 7 per cent

[*] This Journal, III, xxxvi, 295, xxxviii, 329, and Bull. U. S. Geol. Survey, No. 60, p. 131.

[†] This Journal, III, xix, 220.

[‡] Geol. För. Förh., vii, 59, and Journ. prakt. Chem., xxix, 191.

existed and his UO_2 being moreover much too low. A reexamination of the Norwegian mineral seemed desirable, and thanks to Professors W. C. Brögger and A. E. Nordenskiöld, who kindly furnished material from several quarries about Moss and from Arendal, this was rendered possible. The results were surprising and established beyond question that the formula found by Blomstrand was purely accidental, that the mineral from different quarries varied in composition and in such a manner that it was inadmissible to suppose that the occurrence analyzed by him represented the pure material from which the others might have been derived by alteration. The most surprising discovery, however, was that nitrogen is an integral component of most uraninites and possibly of all, in quantities ranging from mere traces up to over 2·5 per cent.

The nitrogen is set free from the mineral as nitrogen gas by the action of a non-oxydizing inorganic acid, and by fusion with an alkaline carbonate and probably also caustic alkalies in a current of CO_2. As obtained by the use of acids the gas is colorless, odorless, a non-supporter of combustion, unchanged by mixture with air, neutral to litmus papers, not absorbed by caustic alkalies, and insoluble in water, at least its coefficient of absorption is so small as to be inappreciable without elaborate experimentation. When subjected in a eudiometer to the ordeal prescribed by Bunsen * there results no alteration in volume, other than that caused by the union of the hydrogen and oxygen added.

This evidence, while fairly conclusive as to the nature of the gas, was purely negative, and proof of a more positive character was sought. Nitric acid is formed from a moist mixture of the gas with pure oxygen by long continued passage of the electric spark, and ammonia is produced by the so-called silent discharge through a mixture of the gas with three volumes of electrolytic hydrogen. The contraction produced in the latter case could be measured by cubic centimeters, and water used as an absorbent of the ammonia colored red litmus paper deep blue, besides giving a strong ammonia reaction with Nessler's reagent. With dilute hydrochloric acid as an absorbent there was obtained an abundant precipitate of ammonium platinic chloride. In a Geissler tube under a pressure of 10^{mm} and less the gas afforded the fluted spectrum of nitrogen with great brilliancy.

Special attention was paid to the estimation of UO_2, or more properly of the oxygen required to effect complete oxidation after solution of the mineral in sealed tubes with sulphuric acid. It was found that concordant results were only to be obtained when the tubes were filled with CO_2 from

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* Gasometrische Methoden, 2d ed., pp. 73 and 74.

a generator and not by the introduction of Na_2CO_3 into the tubes themselves. With the observation of this and other precautions detailed in the unabridged article the results of titration with $KMnO_4$ leave nothing to be desired as regards accuracy.

The analyses which follow were with two exceptions—V and XVIII—made before recognition of the nature and importance as regards quantity of the gas given off by acid, and their object was chiefly to ascertain the relative percentages of UO_3, UO_2, and rare earths with a reasonable degree of closeness. Unusual pains to secure very accurate summations were therefore not taken except in analysis V, and this was unfortunate as will appear later.

North American Uraninites.

	Connecticut.									
	Glastonbury.					Branchville.			Colorado.	Carolina.
	I.	II.	III.	IV.	V.	VI.	VII.	VIII.	IX.	X.
UO_3	22·08	23·35	22·22	26·48	23·03	13·27	21·54	14·00	25·26	50·83
UO_2	59·13	58·01	59·31	57·43	59·93	72.25	64·72	70·99	58·51	39·31
TiO_2									trace.	
ZrO_2? ...							·33		7·59	
ThO_2 ...	9·57	9 78	10·31	9 79	11·10	7·20	6·93	6·52		2·78
CeO_2				·25					·22	·26
$(La,Di)_2O_3$		·46		·13						·50
$(Y,Er)_2O_3$				·20						·20
Fe_2O_3 ...	1·21	·33	·67	·40	.29	·11	·28	·27		trace.
PbO	3·14	3·24	3·07	3·26	3.08	4·35	4·34	4.35	·70	4·20
ZnO									·44	
FeO									·32	
MnO				trace.		·10	·07	?	·16	
CaO	·08		undet.	·08	·11	·18	·22	·30	·84	·85
MgO								·15		·30
Alk.										
H_2O	·97	undet.	undet.	·61	·43	·68	·67	·68	1·96	1·21
N	undet.	undet.	undet.	undet.	2·41	undet.	undet.	2·63	·15	·37
SiO_2	1·06		·25	·16	·16	·03	·13	·20	2·79	·08
P_2O_5					·02				·22	?
As_2O_5 ...									·43	
Fl					·04					
$CuFeS_2$ ..									·12	
FeS_2									·24	
Cb_2O_5 ...	·96									
Insol. ...	·85	1·74	·42	·70	·89	·04	·14	1·40		·10
Total	99·05	96·91	96·25	99·49	101·49	98·21	99·37	101·49	99·95	100·99
Sp. G. ...	9·139	9·051		9·587	9·622	9·733	9·560	9·348	8·068	9·086

Comstock and Blomstrand both assumed that the iron found by them existed as FeO, but for reasons which cannot be detailed in this paper I have preferred to consider it generally as Fe_2O_3. The values given for UO_3 and UO_2 are therefore subject to a correction if this assumption should prove unwarranted, but the amount of iron found is so small as to affect in no way the conclusions drawn from the analyses. It is highly probable from an experiment made on the material of analysis V that none of the iron belongs to uraninite, but is simply derived from foreign bodies from which it is practically impossible to free the mineral entirely. It is probable that in all cases but V and XVIII the total percentage of earths is somewhat too low. Oxalic acid always leaves a portion of the earths with uranium, and the remainder can only be recovered by precipitation as nitrates by ether from a neutral solution. This was done only in the two cases mentioned, which in point of time post-date all other analyses.

Norwegian Uraninites.

	Anneröd.	Elvestad.	Elvestad.	Skraatorp.	Huggenäskilen.	Arendal.	Arendal.
	XII.	XIII.	XIV.	XV.	XVI.	XVII.	XVIII.
UO_3	30·63	25·36	22·04	32·00	35·54	41·71	26·80
UO_2	46·13	50·74	43·03	43·88	43·38	24·18	44·18
ZrO_2?	·06	·08	8·43				
ThO_2	6·00	8·48		8·98	6·63	3·66	4·15
CeO_2	·18	·21		·17	·20		none
$(Di,La)_2O_3$	·27	·26		·36	·23		·67
$(Y,Er)_2O_3$	1·11	1·10		·97	1·03	9·76	9·05
Fe_2O_3	·25	·21	·30	·09	·32	·03	·24
PbO	9·04	10·06	8·58	9·46	9·44	10·54	10·95
MnO		·06					
CaO	·37	·77	·37	·36	·41	1·06	·61
MgO	trace.	trace.	·13	trace.	·13	·10	·04
Alk.						·23	·15
H_2O	·74	·73	·74	·77	·79	1·23	undet.
N	1·17	1·28	1·08	1·03	1·08	undet.	1·24
SiO_2	·22	·38	·29	·53	·49	·90	·50
P_2O_5	·02	·04	trace.	?	trace.		trace.
Insol.	4·42	·45	15·45	1·54	·42	1·10	1·19
Total	100·61	100·21	100·44	100·14	100·09	94·50*	99·77
Sp. G.	8·893	9·145	8·320	8·966	8·930	7·500	

Want of space forbids reproducing in this article numerous explanatory notes and the separate figures of which the above are in many cases the mean, without which the accompanying tables should on no account be used as a basis for criticism.

The Glastonbury material was all from Hales's quarry in the town of Glastonbury, a few miles N.E. of Middletown, and was obtained through various channels. That from

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* The loss in this analysis is supposed to be mainly accounted for by CO_2.

Branchville was received from Professors Brush and Dana, and was the residue of the material from which Comstock had taken his for analysis. No. VI was by far the purest of any material obtained from any locality. It is earnestly to be hoped that more of this excellent material may be found for closer investigation, since it possesses the greatest density and the highest percentage of UO_2 and N of any known variety, besides representing the extreme of perfection as regards crystallization and purity.

The Colorado mineral differs from all other American occurrences in that it is devoid of crystalline form and that thoria is wanting, its place being apparently supplied by zirconia. It moreover contains the least amount of lead of any known uraninite. The North Carolina material was analyzed mainly to learn if rare earths enter into its composition. No. X represents the composition of the purest sample available, and No. XI of the residue after extraction of the yellow oxidation products by very weak HCl. No really unaltered uraninite appears to have been found in North Carolina.

Of the Norwegian specimens those analyzed under XII and XIII were from Professor W. C. Brögger, the remainder from Professor A. E. Nordenskiöld. XII is the original Bröggerite of Blomstrand, while XIII is "so viel ich weiss von derselben Stelle wie das Originalmaterial Lorenzens" (Brögger). Those from Professor Nordenskiöld all bore erroneously, with exception of that from Arendal, the name Cleveite.

In the following table all the foregoing analyses of Norwegian material have been re-calculated to the percentages found, excluding the insoluble matter, in order that their true relations may appear at a glance, whereby the sum of the rare earths combined is given instead of each earth or group of earths by itself. Only those constituents are tabulated which may be considered unquestionably in whole or in part as belonging to the uranium mineral.

	XII.	XIII.	XIV.	XV.	XVI.	XVII.	XVIII.
UO_3	32·04	25·48	26·04	32·50	35·69	42·11	27·12
UO_2	48·25	50·97	50·83	44·57	43·56	24·51	44·71
Earths	7·97	10·18	9·96	10·64	8·12	13·57	14·03
PbO	9·45	10·11	10·14	9·61	9·48	10·66	11·08
CaO	·39	·77	·45	·36	·41	1·07	·62
H_2O	·77	·73	·87	·78	·79	1·23	?
N	1·23	1·28	1·28	1·05	1·08	?	1·26

An examination of analyses XII to XVI as re-calculated hardly allows of any other conclusion than that the specimens n the above four different quarries about Moss belong to and the same mineral species, just as may be said of the ıeral from the two Connecticut localities. While analysis [differs in some respects from Blomstrand's analysis of ıggerite it simply serves to show that the mineral may vary :omposition in the same quarry. Leaving out of considera- ı for the present the nitrogen, it is certain that the ortho- nate formula derived by him from his analysis cannot be ained from No. XII. A comparison of analyses XIII and V with Lorenzen's analysis,* coupled with Professor Brög- 's words given above and the fact that not one of the speci- ıs from the neighborhood of Moss above analyzed contains than 8 per cent of earths, gives rise to the strongest possible picion that that analyst has overlooked thoria altogether, withstanding the fact that the present material is from estad and Lorenzen's was from Huggenäskilen. The pos- lity of a mistake as to the source of Lorenzen's material is gested by the totally different ratio between UO_3 and UO_2 he specimen from Huggenäskilen sent by Professor Nor- skiöld (No. XVI). If it should prove that Lorenzen over- ked thoria, another of Blomstrand's supports in favor of the ıo-uranate formula for all uraninites, including Bröggerite Cleveite, is knocked away, the first being the earlier and hown incorrect analysis of Branchville uraninite.

he oxygen ratios calculated for analyses XII to XVI, nting all earths as thoria, whereby the comparison is very le affected, since the percentages of other earths are almost :e in all analyses, are as given below, as also the ratio for mstrand's Bröggerite, in which FeO has been changed to O_3 and a corresponding change made in the UO_3 and UO_2 ırder to compare properly with the others.

	Mol. Wt.	XII.		XIII & XIV.		XV.		XVI.		Bröggerite.	
....	287	5·36	1	4·31	1	5·44	1	5·96	1	6·07	1
....	271	5·70	1·37	6·01	1·85	5·26	1·33	5·14	1·14	5·15	1·11
hs ..	266	·96		1·21		1·28		·98		1·02	
....	223	·68		·73		·69		·68		·60	

t is seen that none of the ratios conform even approximately that for Blomstrand's analysis except that of the mineral :n Huggenäskilen. A re-calculation of all with Fe_2O_3 instead FeO and consequent changes in UO_3 and UO_2 and separation he earths would give the normal ratio 1 : 1 for Blomstrand's lysis, but the others would differ from it more widely than he above exhibit.

Nyt Mag. f. Naturv., xxviii, 249. UO_3 38·23, UO_2 50·42, PbO 9·72, FeO ·25, ·21, H_2O ·70, SiO_2 ·31 (99·84).

The correctness of the ortho-uranate formula for Bröggerite itself having been invalidated by the difference between his own and analysis XII above, it is hardly worth while to discuss its applicability to the Bohemian and Saxon uraninites of which no complete and reliable analyses have been made except perhaps the single one by Ebelmen in 1843, which on re-calculation by Blomstrand was found to conform to his view. It can hardly be doubted that had Blomstrand been able to analyze material from more than one quarry about Moss he would have seen the impossibility of reconciling the discrepancies in composition so as to admit of the application of one general formula.

It is apparent notwithstanding the deficiency of earths and one or two other discrepancies, that analysis XVII was really made upon Cleveite as the label indicated. The density too corresponds exactly with that found by Nordenskiöld.[*] From a comparison of analyses and reasoning which cannot be here set forth for want of space, it is in the highest degree probable that the Cleveite of Nordenskiöld, the Nivenite of Hidden and Mackintosh,[†] and the material of analysis XVII are identical or represent slightly different stages of alteration of one and the same original species. What this species is is pretty clearly indicated by analysis XVIII where the earths are in about the same proportion as in XVII, but the UO_2 and UO_3 stand in a very different ratio. The material of this was likewise from Arendal and presumably from the precise locality of that of analysis XVII, since the pieces were in one package without distinguishing labels. Its extreme solubility[‡] compared with the other Norwegian uraninites is shared by that of analysis XVII, by Cleveite, and by Nivenite, and is to be explained probably not so much by advanced decomposition as by the preponderance here of a more soluble yttrium-uranium compound. Whether this last Arendal material is the same whence Cleveite and its American representative have been derived by alteration, as seems most probable, or not, it is in any event a true uraninite of more basic character than any of the Norwegian thorium-uraninites, and consequently conforms still less than those to the ortho-uranate formula.

Only traces of nitrogen were found in uraninite from Przibram, Joachimsthal, and Johanngeorgenstadt. None of the specimens contained zirconia, thoria, or other rare earths.

[*] Geol. För. Förh., iv, 28, and Zeitschr. f. Kryst., iii, 201.

[†] This Journal, III, xxxviii, 481.

[‡] In this connection it may be remarked that the greatest difference exists between the solubility of the Norwegian and the American uraninites. While 12 hours is more than sufficient to effect complete decomposition of any of the former by very dilute H_2SO_4 at 100° C., nine days is insufficient for the Connecticut mineral.

Owing to the uncertainty of being able to determine with any close approach to truth the proportions of UO_2 and UO_3 in the presence of sulphides and compounds of arsenic and vanadium, no quantitative analyses of specimens from those localities have as yet been made.

Hitherto the analyses have been considered without reference to the nitrogen. It has been sought to show on grounds which would be valid even without its presence that the ortho-uranate formula is capable of no general application to uraninite, and that in the one or two cases where it does seem to apply this agreement is probably accidental. Taking into account the low atomic weight of nitrogen as compared with uranium, thorium, and lead, it is plain that it must play an important part in the constitution of the molecule, and that therefore its discovery without other evidence furnished by the analyses is sufficient to invalidate entirely the practically identical formulæ of Comstock and Blomstrand. Throughout the whole list of analyses in which nitrogen has been estimated the most striking feature is the apparent relation between it and the UO_2. This is especially marked in the table of Norwegian uraninites recalculated, from which the rule might almost be formulated that, given either nitrogen or UO_2 the other can be found by simple calculation. The same ratio is not found in the Connecticut varieties, but if the determination of nitrogen in the Branchville mineral is to be depended on, the rule still holds that the higher the UO_2 the higher likewise is the nitrogen. The Colorado and North Carolina minerals are exceptions, but it should be borne in mind that the former is amorphous like the Bohemian and possesses the further similarity of containing no thoria, though zirconia may take its place, and the North Carolina material is so much altered that its original condition is quite unknown.

In the absence of all positive knowledge as to the rôle which nitrogen plays in the mineral it would be idle to speculate at present upon the proper position of the latter in mineral classification. Much remains to be done before this question can be elucidated.

But two explanations seem possible to account for the wide differences in the oxygen ratios for UO_3 and total bases, varying as they do, from 1:4·37 for the Branchville material of analysis VI to 1:1 for Blomstrand's Bröggerite and even to a ratio indicating acidity for Nivenite. Either all the others are alteration products of a mineral having the composition of the Branchville occurrence, or even of some unknown body entirely free from UO_3; or they are mixtures of two or more substances. Fractional solution indicates this prettly clearly without deciding between them, for when Glastonbury uraninite was subjected to the action of sulphuric or hydrochloric acids for different periods of time the residue was found to be enriched in UO_2 and likewise in nitrogen, and this enrichment was more or less according as much or little of the mineral had been dissolved.

Whatever may be the eventual conclusion it will be found that the small amount of water afforded by all analyses must be carefully considered. Small as this quantity is, in consequence of its low molecular weight as opposed to uranium, thorium, and lead, it must play an important part in the mineral as a homogeneous whole or in one of its parts if a mixture. In the latter case it will unquestionably be found to belong to the more soluble component.

Attention must be called to one difficulty presented by the analyses for which no satisfactory explanation presents itself. Analysis V was made partly in duplicate with all possible refinements in order to ascertain whether or not the almost constant plus in the summations of those preceding analyses in which all constituents had been determined, or in which it was evident that an excess would result by the estimation of the one or two failing members, was due to impure reagents or to faulty manipulation. The excess still appears, and it seems as if some one of the weighings in all analyses must have been uniformly too high. The cause cannot be sought in a replacement of oxygen by nitrogen in combination with uranium as is often allowable when fluorine is present in a mineral, for since the nitrogen is freed as a gas by sulphuric acid it is immaterial so far as the summation is concerned, whether the proportions of UO_2 and UO_3 as found by titration are correct or not. A certain amount of oxygen has been used, and it does not alter the result whether this has been employed to oxidize a suboxide of uranium to UO_2, supposing nitrogen to have replaced a part of the oxygen in UO_2, or only in oxidizing UO_2 to UO_3. In the former case the actual percentage of UO_2 in the mineral would be increased, but the oxygen consumed would be the same. This matter will be further looked into.

Other very mystifying points have been observed which were revealed in a series of supplementary experiments on Glastonbury uraninite which can here only be outlined in the briefest manner. Experiment having shown that no nitrogen could be obtained by H_2SO_4 or by fusion with an alkaline carbonate after sufficiently long ignition of the mineral in air, it was sought to learn if the final change in weight by such ignition represented the difference between loss of water plus all nitrogen and gain of oxygen from oxidation of UO_2. All experiments made showed a considerable *gain* in weight, whereas there should have been a large *loss* if the nitrogen had been expelled. No other explanation seems possible than that the nitrogen has entered into some other state of combination from which it is not set free by the usual means. A somewhat similar change seems to result from heating the mineral in hydrogen. All UO_3 is reduced to UO_2 and the usual tests show that the percentage of nitrogen decreases very slowly as the heating is prolonged, but the total loss is by no means equal to the sum of water plus oxygen of UO_3 reduced to UO_2 plus the nitrogen that has disappeared; it is slightly, if any, in excess of water and oxygen from UO_3 alone. Ammonia is not formed. Practically no loss in weight occurs on heating the mineral in CO_2 beyond that representing the water.

Briefly summarized the conclusions are as follows:

First. Nitrogen exists in uraninite in quantities up to over 2·5 per cent, and seems generally to bear a relation to the amount of UO_2 present. This is the first discovery of nitrogen in the primitive crust of the earth.

Second. The condition in which the nitrogen exists is unknown, but it is entirely different from any hitherto observed in the mineral kingdom.

Third. Analysis of uraninite from various localities has shown that, with in general the same constituents, the mineral varies widely in composition, and that its physical characteristics and its behavior toward certain solvents are often as distinct as the chemical differences.

Fourth. The formulæ of Comstock and Blomstrand are inapplicable to the zirconia, thoria, and yttria uraninites of North America and Norway, among which are to be reckoned Bröggerite, Cleveite, and Nivenite, and probably to the varieties free from earths.

Fifth. Extended and most careful examination of uraninite specimens from all possible localities is necessary before any conclusion worthy of acceptance can be reached as to the character of the chemical combination or combinations represented by them. The work in this direction should likewise cover a study of the nitrides and oxynitrides of uranium and thorium, with synthetical experiments aiming at the artificial production of uraninite.

Work will continue in this laboratory as opportunity may offer. It is earnestly to be hoped that those possessing or in a position to secure uraninite specimens will take the trouble to examine them on the lines suggested in the foregoing pages, or if unable to do so, will kindly contribute material for examination here. The interest in the matter is not confined merely to a solution of the composition of this one mineral; it is broader than that, and the question arises, may not nitrogen be a constituent of other species in a form hitherto unsuspected and unrecognizable by our ordinary chemical manipulations? And if so, other problems are suggested which it is not now in order to discuss.

Laboratory of the U. S. Geological Survey,
Washington, D. C., June 30th.

ART. L.—*Anthophyllite from Franklin, Macon Co., N. C.;* by S. L. PENFIELD.

As an orthorhombic member of the hornblende group of minerals anthophyllite is of special interest, being a magnesia-iron silicate without calcium, and standing thus in the same relation to hornblende as the orthorhombic enstatite, bronzite and hypersthene do to the monoclinic pyroxene. As far as the author can learn it has never been fully identified from any locality in the United States. Many specimens which may be seen in collections labeled anthophyllite will be found, when examined with the microscope, to be fine fibrous or radiated varieties of hornblende. The material which will be described in the present paper was collected at the dump of the Jenks Corundum Mine, Franklin, Macon Co., N. C., by Mr. Norman Spang, where it is said to occur abundantly, but as it was supposed to be a common mineral only a small specimen was taken away, which he generously gave to the author for determination and investigation.

As anthophyllite is only known from a few localities and as many varieties which have been referred to the species are, according to the analyses, impure or more or less decomposed (indicated by a high percentage of water), a full description of the pure and well crystallized North Carolina mineral seems desirable, especially as the crystals are transparent, rendering it possible to make a fuller determination of the optical properties than has yet been made. The mineral occurs in prismatic crystals, sometimes several centimeters long and nearly 5^{mm} wide in the greatest diameter, imbedded in a green foliated pennine, which latter shows in convergent polarized light under the microscope a uniaxial interference figure with weak positive double refraction. The only forms observed on the anthophyllite are the prism 110, *I* and the brachy-pinacoid 010, *i*-*ĭ*. No terminations could be found, the crystals when traced to the very end in the pennine becoming irregular and much broken. The prismatic faces have a fine luster but are slightly etched; examined under the microscope they appear to be covered with delicate markings with irregular and mostly d contours. They frequently show vertical striations, ially that part of the prism which is nearest to the obtuse , and this is frequently rounded off by the oscillatory ination. Nine of the best selected crystals were measured e reflecting goniometer, but the reflections were somewhat ·tain owing to the striations and surface markings on the ıatic faces. The two best measurements were $I \wedge I$, $\bar{1}10 = 125° 37'$ and 125° 38′, while the average of fifteen ırements each of

$110 \wedge \bar{1}10$, varying from 125° 25′ — 125° 41′ = 125° 35′
$110 \wedge 1\bar{1}0$, varying from 54° 12′ — 54° 34′ = 54° 25′

ɜ take therefore 125° 37′ as the best measurement, it is close to the average given above and will certainly very ʔ represent the true value. From this the ratio $\breve{a}:\bar{b} =$ 5 : 1. The above values vary somewhat from the deter- :ions of Des Cloizeaux* on the anthophyllite from Kongs- in Norway, who gives for $I \wedge I$ about 125°.

e cleavage is very perfect parallel to the prism, 110, and y-pinacoid, 010; the latter is easily produced and yields ınt surfaces although it is always mentioned in the min- ɡies as indistinct. The cleavage parallel to the macro- oid, 100, which is always mentioned as perfect was poor carcely perceptible.

e crystals are very transparent and have a delicate clove- n color, the largest ones affording good material for deter- ıg the optical properties. The plane of the optical axes the brachy-pinacoid, as in all anthophyllites. Two plates cut, one parallel to the macro-pinacoid, the other parallel ɜ base. The latter was small and considerable difficulty experienced in making it at right angles to the good ages. From these two plates the divergence of the optical was measured on a large axial angle apparatus in the sium mercuric iodide solution whose indices of refraction n, red, Li = 1·6650; n, yellow, Na = 1·6811; n, green, 1·7086 with the following results:

	Macro-pinacoid section.	Basal section.
2 H for red	= 87° 31′	87° 24′
2 H for yellow	= 85 45	88 5
2 H for green	= 83 44	88 28

which we can calculate:

2 V red = 90° 4′ β = 1·6276
2 V yellow = 88 46 β = 1·6353
2 V green = 87 28 β = 1·6495

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* Manuel de Minéralogie, i, p. 75.

We see from the above that the optical axes are about at right angles to one another. There is a marked dispersion about the $\breve{a}$ axis, which is $\rho > \nu$, the brachy axis being the acute bisectrix for green and yellow but obtuse for red. One of the prismatic crystals after polishing the faces served as a prism for determining two of the indices of refraction. The prismatic angle after polishing measured 52° 55′. The minimum deviation for yellow was 41° 0′ for rays vibrating parallel to the vertical axis, and 40° 14′ for rays vibrating parallel to the macro-axis, from which we calculate $\gamma = 1{\cdot}6404$ and $\beta = 1{\cdot}6301$, while β above was found to be 1·6353. From the values of 2V, γ and β for yellow we calculate $\alpha = 1{\cdot}6288$. The optical orientation is therefore $\breve{a} = \mathfrak{a}$, $\bar{b} = \mathfrak{b}$ and $\dot{c} = \mathfrak{c}$. The double refraction is negative for green and yellow, $\breve{a}$ being the acute bisectrix and positive for red, $\dot{c}$ being the acute bisectrix.

Hardness about 6. Specific gravity, by floating in the heavy solution, 3·093.

The purest crystals were selected for analysis by hand-picking which was easily accomplished as the mineral separated readily from the matrix.

The results of analysis on the air-dry powder are as follows:

		Ratio.	
SiO_2	57·98	·966	
FeO	10·39	·144	·963
MnO	·31	·005	
MgO	28·69	·717	
CaO	·20	·004	
H_2O	1·67	·093	
Al_2O_3	·63		
Loss at 100°	·12		
	99·99		

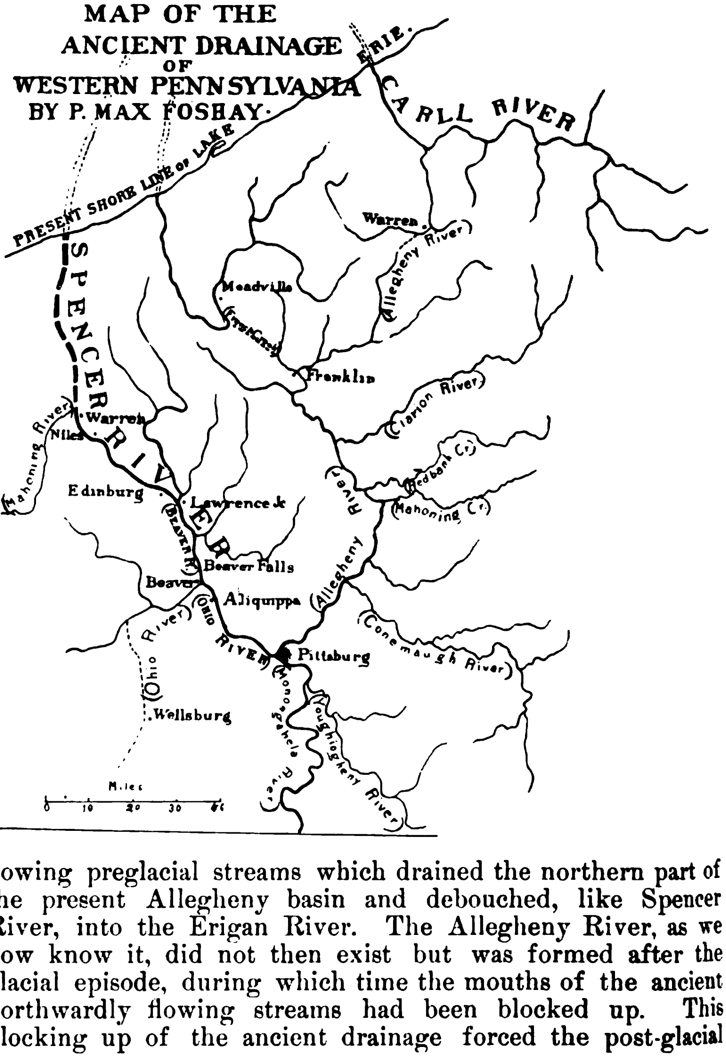
The ratio of $SiO_2 : RO$ (H_2O being included) is ·966 : ·963 or almost exactly 1 : 1, giving the formula $RSiO_3$, R = Mg, Fe, H_2 and traces of Mn and Ca. The mineral when heated in a closed tube over a Bunsen burner was found to be anhydrous and the analysis was made accordingly. After drying the powder at 100° C, the mineral was heated to faint redness in a crucible and lost only 0·19 per cent. On summing up the analysis, which was very carefully made and everything tested, a deficiency of 1·50 per cent was found and moreover the ratio of $SiO_2 : RO$ = ·966 : ·870, which indicated a large excess of silica. In trying to account for this deficiency a second sample of the mineral was heated over a blast lamp in a closed glass tube when water was given off in perceptible quantities. The H_2O in the analysis was determined by loss of weight on igniting in a current of CO_2 gas to prevent oxidation. A second sample was ignited in a closed crucible without CO_2 gas and gave almost the same result, 1·71 per cent. In this sample the FeO was determined, after solution in hydrofluoric and sulphuric acids, and after reduction the total iron. As the mineral after such strong ignition was only slowly acted on by the hydrofluoric acid and in the experiment only partially dissolved, the results were not thoroughly satisfactory but they proved conclusively that the FeO had only been oxidized to a trifling extent and the loss on ignition will represent therefore very nearly the exact percentage of H_2O. That the tendency of FeO, in this combination, to oxidize is not very great is moreover proved by the fact that repeated ignition did not yield any increase in weight. That the H_2O is an essential constituent of the mineral and is not the result of alteration, is proved by the fact that it is very firmly united to the molecule, requiring an intense heat to drive it off, and moreover it is just sufficient to bring the ratio of protoxides to silica = 1 : 1. The transparency of the crystals would moreover prove that the material which was analyzed was very pure and had not suffered any alteration.

Mineralogical Laboratory, Sheffield Scientific School
New Haven, May, 1890.

ART. LI.—*Preglacial Drainage and Recent Geological History of Western Pennsylvania;* by P. MAX FOSHAY, M.S., F.G.S.A.

THE investigation into the preglacial drainage of Western Pennsylvania, of which this paper is a partial record, was primarily incited by a suggestion thrown out by Professor J. W. Spencer, in a paper read before the Am. Phil. Soc., March 18, 1881. Professor Spencer there advanced the hypothesis that the Beaver River, with part of the Ohio, had in preglacial times constituted a stream which flowed up the modern Mahoning through its now buried channel into the Erigan River (Spencer) which then traversed the basin of Lake Erie. This stream, now become parts of several modern rivers, I have named Spencer River in honor of the investigator who first suggested its existence and to whom is due so large a proportion of our present knowledge of the preglacial drainage of the region of the Great Lakes. Spencer River drained an area nearly co-extensive with that of the Pennsylvania portion of the modern Ohio with its tributaries, including the basin of the Monongahela and part of that of the Allegheny, thus carrying off the rainfall of almost all Western Pennsylvania and Eastern Ohio.

The preglacial drainage of Northwestern Pennsylvania and Western New York was long since thoroughly worked out by Professor John F. Carll, who was the pioneer in this field. In the course of his survey in Northwestern Pennsylvania he collected proof* of the existence of at least two northwardly flowing preglacial streams which drained the northern part of the present Allegheny basin and debouched, like Spencer River, into the Erigan River. The Allegheny River, as we now know it, did not then exist but was formed after the glacial episode, during which time the mouths of the ancient northwardly flowing streams had been blocked up. This blocking up of the ancient drainage forced the post-glacial



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* Report III, Second Geological Survey of Pennsylvania, pp. 330–366. John F. Carll, Harrisburg. 1880.

rivers to overflow to the south and cut down their divides. They united to form the modern Allegheny River and thus we have the phenomenon of reversed drainage in the upper Allegheny region. The story of the Beaver valley is to be told in much the same words, but Professor Carll—not having examined the region—did not see as clearly as Professor Spencer the former drainage of this part of the State. He says,* "I strongly suspect that Big Beaver River is a glacial enlargement of a small ancient stream formed in the same manner as those found in the summit basins and that anterior to the Ice Age the Shenango and other headwater streams of the Beaver, including the Connoquenessing, delivered northwardly through the Mahoning and Grand Rivers into Lake Erie basin. . . . ." If he had placed the ancient divide, cut through during the Glacial Epoch, in the present Ohio valley somewhere between the mouth of the Little Beaver and Wellsburg, W. Va., instead of placing it in the Beaver valley, he would have been correct, as will be seen below.

The evidence that Spencer River, whose bed is now buried beneath many feet of drift materials, once flowed northwardly is to be found in a very complete series of measurements of the depth of the drift filling taken from the records of oil and gas wells drilled in the valleys during recent years. In the table below I give only maximum depths at not too frequent intervals but it must be understood that there is hardly a mile of the distance covered in which there are not one or more records showing the presence of the old channel.

	Dist. from Pittsburgh.	Place.	Low Water. A. T.	Depth of Filling.	Old Floor. A. T.
1.	0·	Pittsburg.	699 ft.	44 ft. †	655 ft.
2.	10·	Coraopolis.	?	50 ft.	?
3.	19·	Aliquippa.	677 ft.	60 ft.	617 ft.
4.	25·2	Beaver.	670 ft.	+60 ft.‡	−610 ft.
5.	29·8	Beaver Falls.	700 ft.	+100 ft.§	−600 ft.
6.	46·8	Lawrence Junc.	760 ft.	+150 ft.‖	−610 ft.
7.	51·4	Edenburg.	780 ft.	200 ft.¶	580 ft.

The figures in the fifth column of the table it will be seen demonstrate a progressive deepening of the drift filling as we go northward and when reduced to tide-level prove that the old floor at present dips slightly to the north.

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* Report III, Sec. Geol. Survey Pa., p. 392—footnote.

† An. Rep. Pa. Survey 1886, Pt. II, p. 730. Jones & Laughlin, Nos. 1 and 2.

‡ Rep. Q, Pa. Survey, I. C. White, 1878, p. 14.

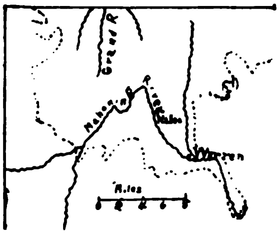
§ Rep. Q, Pa. Survey, I. C. White, 1878, p. 15.

‖ Rep. Q, Pa. Survey, I. C. White, 1878, p. 16, quoted from Dr. J. S. Newberry in Geology of Ohio.

¶ Rep. QQ, Pa. Survey, I. C. White, 1879, pp. 19, 184, 202.

The elevation of No. 6 at the confluence of the Mahoning and Shenango does not constitute an exception as the well from which the record was taken went 150 feet through drift and not having reached rock was abandoned. There is thus a total fall of 75 feet in the 51·4 miles covered by the table, reaching down to an elevation of only eight feet above the present surface of Lake Erie.

The fact of a post-glacial elevation of the northern part of the continent is now well established. The differential uplift shown in the younger beaches about the overlapping ends of Lake Erie and Lake Ontario is about two feet per mile.* Mr. McGee's survey of the rise of the older Columbian drift formation would make the Pleistocene and recent deformation amount to about three feet per mile. Adding this dip to the present profile of the floor of Spencer River we obtain an abundant northward fall of the old bed. Well records at Niles, O., show the presence of the old channel at that point. A few miles north of this point the country falls away towards Lake Erie and a number of country wells give depths of drift filling almost sufficient to *prove* the fall of the old bed far into Grand River basin. In addition to this the Grand River of Ohio, along with the other Ohio Rivers, was shown by Dr. Newberry's survey to have a buried channel amply deep to be a continuation of Spencer River.†



The accompanying figure (fig. 1) shows in dotted line the outcrop of the hard Conglomerate Series as drawn on Orton's geological map of Ohio. The remarkable embayment in this outcrop, heading at Youngstown, O., furnishes strong presumptive evidence of the existence of a reversed drainage in this locality. The Mahoning River after coming into the bay at its side and flowing some miles in the normal direction makes a sudden bend and flows at right angles to its former course *towards* the head of the embayment. The great amount and peculiar form of erosion which the Conglomerate Series has suffered in the formation of this embayment could only have been accomplished by a stream flowing northwardly through the bay in a now deeply buried channel, i. e. Spencer River.

Even disregarding the northward Pleistocene elevation the only other possible outlet for Spencer River is through the valley now occupied by the Ohio below its point of meeting with the Beaver. That this could not have been the outlet is proved by the following facts:—at Smith's Ferry, on the Pennsylvania Ohio State line, two favorably situated measurements give a maximum depth of drift filling of 30 feet* and at Steubenville, O., the channel could not possibly have been deep enough to drain Spencer River.† The conclusion is thus made imperative, independent of the northward crust movements, that this area must have drained northwardly into the Erie basin. This ancient basin would then include the areas now drained by the Lower Allegheny, Clarion, Redbank, Mahoning, Conemaugh, Youghiogheny, Cheat, Monongahela and Little Beaver Rivers. The Monongahela and Allegheny are both known to have buried valleys, the former‡ as far as its junction with the Youghiogheny and the latter§ to somewhere north of Parker.

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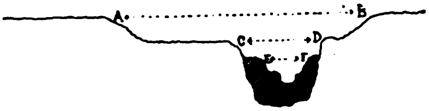
* The Iroquois Beach; by J. W. Spencer. Trans. Roy. Soc. Can., 1889, p. 128.

† Geology of Ohio, vol. ii, p. 199.

The topography of the Beaver Valley is shown in fig. 2, which is an ideal cross-section. It consists first of an old base-level plain (AB) bounded on either side by slopes rising slowly to the level of the table-land which is the basis of the topography of the region; of a rock gorge (CD) extending from 300 to 350 feet below the level of the plain, which is completely filled with drift for the lower 100 feet and partially for the next 125 feet; and of an inner gorge (EF) in the drift whose excavation by the modern river gave us the drift terrace system.



AB, old base-level plain.
CD, outer or rock gorge.
EF, inner or drift gorge.
The shaded portion represents the drift filling of the old rock gorge with its terraces of erosion.

The old base-level plain has more frequently been called the "fourth terrace," though it was known to have no connection with the other terraces. It is a mile or more in width and is covered in all places south of the terminal moraine by a deposit consisting of white or yellowish clay, of variable thickness up to ten feet, which in places contains intermingled pebbles of northern drift, and frequently has sand or gravel above or below it, or both. The maximum observed thickness of the whole deposit is twenty feet. This clay deposit is very constant wherever the old base-level plain—a mere bench often—is found. The plain has in all places, south of the moraine, a rocky scarp on its river side and is always (in the Ohio and lower Beaver valleys) at a higher elevation than any of the Pleistocene terraces. It is most marked in the Beaver valley on account of its being formed for the most part from the more resisting rocks of the Conglomerate Series, but it is easily made out in the Ohio valley from Pittsburg to Beaver and also far up the Allegheny and Monongahela valleys. South of Beaver, on the Ohio, it has not been observed. Ascending the Beaver the plain falls from 915 feet A. T. at Beaver Falls to 890 feet A. T. at the mouth of the Connoquenessing—a distance of ten miles. There can be no doubt that this was once the bed of an ancient river at a time long anterior to the First Glacial epoch, and, from its northward fall, the stream must have flowed in that direction. The plain thus indicates a long epoch,.when the preglacial drainage had not yet cut the deep cañons which marked the topography of the later Tertiary period. The clayey deposit over the plain belongs to a Pleistocene epoch antedating that during which the terminal moraine was formed as it seems to pass beneath the moraine with its kames at the point of contact. It seems to record an episode when the continent was lower than now. Possibly it may be contemporaneous with McGee's Columbia formation(?)

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* Report QQ, I. C. White, Sec. Geol. Survey Pa., 1879, p. 16.
† Report QQ, I. C. White, Sec. Geol. Survey Pa., 1879, p. 17.
‡ Report K, Sec. Geol. Survey Pa., J. J. Stevenson, 1876, p. 20.
§ Report V, Sec. Geol. Survey Pa., H. M. Chance, 1879, ix, x and 19.

Following the period of the base-level plain came long ages of high continental elevation—higher than the present—during which all the streams of Western Pennsylvania cut channels far below their present beds. This epoch (Pliocene ?) was either one of slight precipitation or of comparatively short duration as none of the tributary streams reached a base-level of erosion but were flowing through V-shaped cañons of rather rapid fall when the period of the terminal moraine with its subsidence filled all these old channels with drift to nearly the level of the old base-level plain. During all the foregoing time Spencer River had drained the region in question, its waters delivering into the Erie basin. After the deposit of the drift in the valleys of Pennsylvania a divide was formed across the old channel of Spencer River at Orwell, O., and the drainage of the region became for the most part reversed—the waters now finding their way into the lower Ohio and thence to the Mississippi.

The northern elevation of the continent so thoroughly worked out by Gilbert and Spencer in New York and Ontario occurred at this same time and so confirmed the region in its drainage to the south. The modern rivers now began eroding their beds of drift and are still at work. That this process has gone on uninterruptedly for a long period of time is shown by the fact that many of the tributaries of the Beaver and Ohio have flat flood plains, underlaid by the buried channels of the former drainage level, extending two miles or more back from e river. There is every indication however of a very modern evation (40± feet) of the region, accompanied by a rapid epening of the main channels of drainage, in the fact that ese tributaries have but recently begun eroding their beds ar their mouths. This process has in no case extended more an one-fourth mile. In thus eroding their beds the streams many cases have deepened their channels in lines which do t correspond with their buried channels but lie to one side the other; and so we find them running over ledges of rock ar their mouths, which has led many observers to the conclu- n that the tributaries could not flow over buried channels. all cases that I have examined, however, I have found ong evidence of the existence of such channels—of which ere is positive proof in many wells and excavations.

Beaver Falls, Pa., August 9, 1890.

RT. LII.—*On the so-called Perofskite from Magnet Cove, Arkansas;* by F. W. Mar.

In 1877, it was shown by Knop,* that the supposed perof- ite of the Kaiserstuhl, contained besides titanium a consider- le amount (23 p. c.) of niobium and tantalum, and he accord- gly made it an independent species and named it very appro- iately *Dysanalyte.* The analysis of the similar mineral from agnet Cove, Arkansas, the results of which are given below, ows that it is also distinct from perofskite and is to be classed ith dysanalyte. For the material for analysis I am indebted the kindness of Professor E. S. Dana.

The method of analysis was as follows: 0·500 gram. of the refully selected mineral were placed with about 15cm^3 of con- ntrated sulphuric acid in a platinum crucible of 150cm^3 capa- ty and, the whole being covered with a watch-glass that the ogress of the decomposition might be easily observed, boiled r ten or fifteen minutes. The cooled product was poured to 600 or 700 cm^3 of cold water and allowed to stand over ght or until the calcium sulphate was completely dissolved. small residue was usually found and this was put through e same process. Any final residue is silica and sometimes little tantalum or niobium oxide. The former was deter- ined by evaporation with sulphuric and hydrofluoric acids d the remaining oxide was added to the main oxides.

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* Zeitschr. für Kryst., i, 284, 1877.

The solution of the mineral was then made slightly alkaline with ammonia and the precipitated earth filtered off. The lime was thrown out of the concentrated filtrate as oxalate and after evaporation and volatilization of ammonia salts, magnesia was determined in the residue. Alkalies should be found at this point if present. There were none.

The weighed earths obtained as above were fused in sodium carbonate, enough sulphuric acid added to the mass to bring about a bisulphate fusion and then enough more to keep the whole in the liquid condition even when cold. After cooling, the mass was poured into 300 cm^3 of cold water containing 1 grm. of tartaric acid and after separating the iron, in alkaline solution, by hydric sulphide, the titanium, with which go the niobium and tantalum, were separated by the acetic acid process of Professor Gooch.* The greater part of the manganese was separated by an ordinary acetate process and the acid oxides by the strong acetate process. On neutralizing the filtrate from this last with ammonia and boiling, only a trace of some earth was found, showing absence of alumina. The titanium was separated from the weighed oxides by Knop's chlorinating process, and finally the niobium was determined in the mixture of niobium and tantalum oxides by reduction in hydrochloric acid and titration with permanganate after T. B. Osborne.† Only a trace of titanium was found in the niobium and tantalum oxides by the Osborne process with hydrogen peroxides, and the titanium re-estimated by the same process gave practically the same result as before.

A portion of the oxides having been lost during the operation, having gone, as it appeared, with the manganese used to decompose the tartaric acid, another portion of mineral was treated in the same manner as far as this point, and the tartaric acid was destroyed by evaporation in platinum and ignition. No aluminum having been found, the titanium, tantalum and niobium oxides were separated by boiling with dilute sulphuric acid. By evaporation of this filtrate a quantity of earths was obtained. To this was added another portion separated by ammonia from the filtrate (in the same portion of mineral) after separation of lime, evaporation and ignition and solution in hydrochloric acid, and before the precipitation of the magnesia by microcosmic salt. The combined earths were precipitated in a slightly acid solution by oxalic acid in order to separate from any uranium, the cerium and yttrium groups separated by the sodium sulphate process and each precipitated again as oxalate and weighed as oxide. As appears the main portion of the rarer earths belongs to the yttrium group.

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* Proceedings Amer. Acad. of Arts and Sci., N. S., vol. xii, p. 435.

† This Journal, vol. xxx, p. 329.

An attempt was made to take the atomic weight, but the result obtained, 190, is probably too high, the color showing that part of the sulphate was changed to a basic salt. This, however, with the color of the oxides, a reddish-brown, and the fact that the solutions do not yield an absorption spectrum, suggests that a chief portion of the earth is terbium oxide.

The result of the analysis is as follows:

Specific gravity = 4·18.

				Molec. Ratio.			Quantiv. Ratio.	
CaO	33·22	÷ 56	=	·593	·611 or 23	× 2	1·22	=4
MgO	0·74	÷ 40	=	·018				
FeO	0·23	Fe_3O_4						1·52 or 3
	0·50							
Fe_2O_3	5·66	÷ 160	=	·035	·050 or 2	× 6	·300	
$[Yt, Er, Tr]_2O_3$	5·42	÷ 428	=	·012				=1
$[Ce, La, Di]_2O_3$	0·10	÷ 328	=	·003				
Nb_2O_5	4·38	÷ 268	=	·016	·027 or 1	× 10	·270	=1
Ta_2O_5	5·08	÷ 444	=	·011				2·43 or 5
TiO_2	44·12	÷ 82	=	·538	·539 or 20	× 4	2·156	=7
SiO_2	0·08	÷ 60	=	·001				
	99·53							

In conclusion I would express my thanks to Professor Gooch of the Kent Laboratory for the valuable advice and assistance freely given by him during the course of the analysis.

Kent Laboratory, Yale University, July, 1890.

ART. LIII.—*Experiments upon the Constitution of the Natural Silicates;* by F. W. CLARKE and E. A. SCHNEIDER.

[Continued from p. 312.]

4. *The Chlorite group.*

In this interesting but very obscure group of minerals, three species were examined. First, the dark-green, broadly foliated, mica-like ripidolite from Westchester, Pennsylvania. This mineral has been repeatedly analyzed, and our results confirm the older data. Second, a dark-green, scaly-granular prochlorite, found in excavating the water-works tunnel in Washington, D. C. Third, leuchtenbergite from the Schischimsk mine near Slatoust, Siberia. The last mineral was kindly sent us by Mr. A. Lösch of St. Petersburg; but it unfortunately contained inclusions which render our work upon it of little value. The prochlorite was examined microscopically by Mr. Lindgren of the U. S. Geological Survey, who found it to be quite homogeneous. Analyses as follows:

	Ripidolite.	Prochlorite.	Leuchtenbergite.
SiO_2	29·87	25·40	32·27
Al_2O_3	14·48	22·80	16·05
Cr_2O_3	1·56	....	....
Fe_2O_3	5·52	2·86	4·26
FeO	1·93	17·77	·28
NiO	·17	....	....
MnO	....	·25	....
MgO	33·06	19·09	29·75
CaO	....	....	6·21
H_2O	13·60	12·21	11·47
F	....	trace	....
	100·19	100·38	100·29
H_2O at 105°	....	·80	·38
“ 250°–300°	·95	·15	·21
“ 383°–412°	·49	·62	....
“ 498°–527°	....	·09	....
“ red-heat	11·74	10·55	10·69
“ white-heat	·42	....	·19

Here again we have to deal with water which is plainly constitutional. Hence the suggestion put forward by one of us that the chlorites are essentially micas plus water of crystallization, must be abandoned.*

Upon treatment with dry hydrochloric acid gas at 383°–412°, the three minerals differ considerably. The times of heating and the bases converted into chlorides were as follows:

	Ripidolite.	Prochlorite.	Leuchtenbergite.
Hours heated	19	31	34
MgO removed	13·46	1·54	6·29
R_2O_3 removed	4·24	2·17	·42
SiO_2 removed......	·92	....	....

In a second experiment with the ripidolite 58 hours of heating were required before constant weight was attained, and 13·36 per cent of magnesia plus 1·20 of sesquioxides were rendered soluble. In a third experiment the heating lasted 30 hours, and the percentages of MgO and R_2O_3 removed were 11·10 and 3·31 respectively. Even at the ordinary temperature of the laboratory ripidolite was decidedly attacked by the gaseous acid, 4·66 MgO and 3·43 R_2O_3 becoming soluble. In this case the experiment lasted 100 hours. In the case of the prochlorite the result obtained is of very doubtful significance. In a mineral containing so large a proportion of ferrous iron, secondary reactions due to oxidation are possible, and it is not practicable to determine exactly what changes have taken place The group —Fe—OH might behave like MgOH, and yet subsequent alteration might prevent any estimate of the extent of the reaction.

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* Clarke, "A theory of the mica group," this Journal, Nov., 1889.

By digestion with strong, aqueous hydrochloric acid, both ripidolite and prochlorite were completely decomposed. Leuchtenbergite, on the other hand, left an insoluble residue, resembling garnet, which was originally present as an inclusion in the mineral. All of these minerals decompose with aqueous acid more slowly than the serpentines.

By sharp ignition, ripidolite and prochlorite give up in the free state small quantities of silica, which are determinable by extraction with soda solution. The percentages were as follows:

	Ripidolite.	Prochlorite.
SiO_2 liberated	2·98	2·45

These quantities represent only one-tenth of the total silica in the minerals, and have no evident significance in a discussion of the chemical structure.

Although ripidolite is readily decomposable by aqueous hydrochloric acid, it appears to be split up by prolonged ignition into a soluble and an insoluble part. A weighed quantity of the mineral was heated for nine hours over the blast-lamp, and then digested for three days with hydrochloric acid of sp. gr. 1·12. The residue amounted to 48·47 per cent of insoluble matter, from which boiling with sodium carbonate solution extracted 28·73 of silica belonging to the decomposed silicates. The final undissolved residue, 19·74 per cent, was analyzed; and, treated as an independent substance, gave as follows:

SiO_2	6·32
Sesquioxides	67·81
MgO	25·67
	99·80

If the small quantity of silica here found, only 1·25 per cent of the original material, be neglected as non-essential, the remainder, 18·49 per cent of the ripidolite, has exactly the composition of spinel. Like spinel it is quite insoluble, and in all reasonable probability it may be regarded as that compound. The formation of such a magnesian aluminate, $MgAl_2O_4$, is peculiarly suggestive when we come to consider the structure of the chlorites.

Similar experiments with the prochlorite gave similar but not identical results. After long ignition, six hours, and three days' digestion with hydrochloric acid, 35·61 per cent of residue remained, of which 18·16 per cent was insoluble in carbonate of soda. This last residue, however, was rich in silica, and therefore could not be spinel. The reaction deserves further study; but the oxidizability of the iron in prochlorite introduces elements of uncertainty which would render it very difficult to interpret the results.

In the case of the leuchtenbergite, little else was done. By means of Thoulet's solution 5·62 per cent of a yellowish garnet were separated from the mineral, which accounts for part, but not all, of the lime found in the analysis. On this species our results are of little value, except as regards the character of the water which it contains, and its comparative behavior towards gaseous HCl.

Now, in order to discuss the formulæ of the three chlorites, we may reject as adventitious the small quantities of water given up at or below 300°. This leaves as essential water in ripidolite, prochlorite, and leuchtenbergite, 12·65, 11·26, and 10·88 per cent respectively. Using these figures for water the analyses give the following molecular ratios.

	Ripidolite.	Prochlorite.	Leuchtenbergite.
SiO_2	·498	·423	·538
R_2O_3	·186	·241	·185
RO	·855	·727	·858
H_2O	·703	·626	·604

Hence we have the following empirical formulæ:

Ripidolite	$19R_2O_3$, 86RO, $70H_2O$, $50SiO_2$
Prochlorite	$24R_2O_3$, 73RO, $63H_2O$, $43SiO_2$
Leuchtenbergite	$19R_2O_3$, 86RO, $60H_2O$, $54SiO_2$

And these, reduced to an orthosilicate basis become

Ripidolite	$R'''_{38}R''_{86}H_{140}(SiO_4)_{50}O_{113}$
Prochlorite	$R'''_{48}R''_{73}H_{126}(SiO_4)_{42}O_{127}$
Leuchtenbergite	$R'''_{38}R''_{86}H_{120}(SiO_4)_{54}O_{95}$

This excess of oxygen over the orthosilicate ratio can only be interpreted as basic hydroxyl; whence we get

Ripidolite	$R'''_{38}R''_{86}H_{27}(SiO_4)_{50}(OH)_{113}$
Prochlorite	$R'''_{48}R''_{73}\ (SiO_4)_{42}(OH)_{127}$
Leuchtenbergite	$R'''_{38}R''_{86}H_{25}(SiO_4)_{54}(OH)_{95}$

The last of these formulæ is vitiated by the fact that the mineral analyzed was impure; a fact which appears in the low figure for the hydroxyl, which garnet does not contain. Otherwise it is clear that in general leuchtenbergite and ripidolite agree quite nearly with each other. The question now to be answered is, how shall the hydroxyl be apportioned between the bases?

Taking ripidolite as the mineral of the three which has been most completely examined, we may recall that two concordant experiments with gaseous hydrochloric acid gave 13·36 and 13·46 per cent of removable magnesia, presumably representing the group MgOH. In mean, these percentages correspond to 34 atoms of magnesia. Regarding this as an index of the MgOH present, we may combine the remainder of the hydroxyl with the sesquioxides to form the univalent group AlH_2O_2, and the ripidolite formula now becomes $(AlH_2O_2)_{38}(MgOH)_{34}R''_{52}H_{27}(SiO_4)_{50}$; with three oxygen atoms unaccounted for and negligible. Generalizing this expression we have

$$R''_{52}R'_{99}(SiO_4)_{50},$$

or almost exactly, $R''_2(SiO_4)_2R'_4$.

This is an olivine formula, with half of the R'' replaced by R'_2, and is strictly comparable with the formula of serpentine. It will be remembered that von Wartha* some time ago advanced the opinion that the chlorites and serpentines form one continuous series of minerals, and his view is by this discussion curiously supported. Furthermore, the probable juxtaposition of the groups AlH_2O_2 and MgOH in ripidolite accounts in great measure for the apparent formation of spinel when the mineral is decomposed by heat.

The ratios found by analysis between H, MgOH, and AlO_2H_2, indicate that ripidolite is probably a mixture of two isomorphous molecules; and the observed data are best satisfied by assuming the compounds $Mg_2(SiO_4)_2(MgOH)_3H$ and $Mg_2(SiO_4)_2(AlO_2H_2)_3H$ in equal proportions. For a mixture of these molecules in the ratio of 1 : 1, the composition is easily calculated; and the results agree well with the analysis. If, in the latter, we recalculate the ferric and chromic oxides to their equivalent in alumina, and compute the ferrous oxide as magnesia, reducing the summation afterwards to 100 per cent, we get the following direct comparison between analysis and theory:

	Found.	Theory.
SiO_2	31·18	31·09
Al_2O_3	19·87	19·82
MgO	35·74	36·27
H_2O	13·21	12·82
	100·00	100·00

A closer concordance could hardly be expected.

For prochlorite, notwithstanding the uncertainty as to the behavior of the ferrous iron, similar ratios appear. The expression $R'''_{46}R''_{73}(SiO_4)_{42}(OH)_{127}$ reduces to $(AlH_2O_2)_{46}(R''OH)_{31}$ $R''_{42}(SiO_4)_{42}$; in which $R''OH$ is mainly $Fe''OH$ and R'' is almost entirely Mg. This, generalized, becomes $R''_{42}(SiO_4)_{42}R'_{78}$, which is quite nearly the olivine-serpentine type of formula. A mixture of such molecules in which R' is satisfied by MgOH, FeOH, and AlH_2O_2 in the ratio of 1 : 3 : 6; would have the subjoined composition; which is comparable directly with the results of analysis.

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* Groth's Zeitschrift, xiii, p. 71, 1887.

	Found.	Calculated.
SiO_2	25·40	24·88
Al_2O_3	22·80	25·37
Fe_2O_3	2·86	
FeO	17·77	17·91
MgO	19·09	19·90
H_2O, essential	11·26	11·94
	99·18	100·00

If the first column were recalculated to 100 per cent, with the ferric iron reduced to its equivalent in aluminum, the agreement would be even closer. In brief, prochlorite seems to have a constitution strictly analogous to that of ripidolite; although, on account of its high proportion of ferrous iron it behaves differently towards gaseous hydrochloric acid. The leuchtenbergite evidently has a similar structure; but the impurities in the sample analyzed preclude us from discussing this species more in detail. Just as the micas are derived by substitution from normal aluminum salts, so the chlorites are derived from normal magnesium silicates; and, in a very curious way the two series seem to approach each other. Thus a compound having the chloritic formula $Mg_2(SiO_4)_2(AlO_2H_2)H_3$, if halved, may be written as if it were a derivative of aluminum orthosilicate analogous to some of the more basic hydromicas; and the close physical similarity between the two groups is thus remarkably emphasized.

5. *The micas.*

In this group only three examples were studied, all of the magnesian or ferro-magnesian class. A. Phlogopite from Burgess, Ontario. The ordinary, slightly brownish, broadly foliated mica, somewhat resembling muscovite. B. Phlogopite from Edwards, St. Lawrence County, New York. The peculiar, non-fluoriferous variety, superficially resembling brucite, described by Penfield and Sperry; whose analysis is thoroughly confirmed by ours. C. A nearly black, broadly-foliated iron mica from Port Henry, New York. Commonly regarded as a lepidomelane. Analyses as follows:

	Burgess.	Edwards.	Port Henry.
SiO_2	39·66	45·05	34·52
TiO_2	·56	....	2·70
Al_2O_3	17·00	11·25	13·22
Fe_2O_3	·27	....	7·80
FeO	·20	·14	22·27
MnO	....	....	·41
(Co,Ni)O	....	....	·30
CaO	none	....	....
BaO	·62	....	....
MgO	26·49	29·38	5·82
Li_2O	....	·07	·04
Na_2O	·60	·45	·16
K_2O	9·97	8·52	8·59
H_2O	2·99	5·37	4·39
F	2·24	....	·34
P_2O_5	trace	....	trace
	100·60	100·23	100·54
Less O	·94		·14
	99·66		100·40

The fractional water determinations gave—

	Burgess.	Edwards.	Port Henry.
H_2O at 105°	·66	....	·57
" 250°–300°	·35	·73	·45
" red-heat	1·98	·73	3·37
" white-heat		3·91	

In all the analyses of this investigation, when much iron was found, the total water was determined directly; so that the figures for the higher temperatures do not represent mere loss on ignition. In these micas the percentages of constitutional water, to be used in the discussion of formulæ, are 1·98, 4·64, and 3·37 respectively.

In the Burgess phlogopite numerous inclusions were observed, consisting of slender prisms, and at our request these were examined microscopically by Mr. Waldemar Lindgren. The mica, according to his examination, is made up of "thin foliæ, under the microscope colorless, dark between crossed nicols; interference figure apparently a cross, not separating into hyperbolas; seemingly uniaxial, but with better instruments it would probably be found to be biaxial with a very small axial angle. Shows excellent asterism, caused by interpositions arranged in three directions cutting each other at an angle of 60°. The inclusions are prisms of a strongly refracting and bi-refracting mineral, so thin as to show brilliant Newton's colors. In spite of the very small thickness, the interference colors are near the white of the first order. Extinction takes place strictly parallel to the prismatic surface. Terminal faces rounded, or unequally developed. Beside prisms there are square or rhomboidal foliæ, probably of the same substance. The inclusions were first observed by G. Rose (Neues Jahrbuch, 1863, p. 91) who regarded them as kyanite. Rosenbusch describes them again, and determines them as tourmaline (Physiog. der Mineralien, p. 486). The prisms certainly correspond well in their optical characteristics to this mineral. Kyanite and apatite are excluded from among the possibilities. Probably, in spite of its apparent abundance the mineral is but a very small fraction of the mica substance. At Mr. Lindgren's suggestion the mica was carefully tested for boron, but none was found. Hence tourmaline, if present, must be in exceedingly small quantities.

On account of the high proportion of titanium in the Port Henry iron mica, this too was examined by Mr. Lindgren, who reports as follows: "It is a dark-brown, unusually deep colored, apparently uniaxial biotite, without inclusions, and especially, as far as examined, free from any titanium mineral." Hence the titanium is to be regarded as a constituent of the mica itself.

The action of gaseous hydrochloric acid upon these micas, at 383°–412°, was almost insignificant. The data are subjoined.

	Burgess.	Edwards.	Port Henry.
Hours heated	12	20	33
MgO removed	·40	1·00	trace
K_2O "	none	·21	·44
SiO_2 "	....	·13	....

In the case of the Port Henry mica some iron was volatilized as chloride. This was estimated; and it was found that the total iron taken out, reckoned as FeO, amounted to only 1·62 per cent. An experiment on the Edwards phlogopite at 498°-527°, lasting 18 hours, gave 1·41 per cent of removable magnesia. This quantity has a possible bearing upon the formula of the mineral.

By aqueous hydrochloric acid all three of the micas were completely decomposed. Hence the Burgess phlogopite could have contained little tourmaline, for that mineral is not soluble in the acid. Moreover, the solubility of the micas prevents us from assuming in either of them an admixture of a muscovite molecule, for muscovite also is insoluble. A careful comparison of the two phlogopites showed that the fluoriferous variety was much more stable towards acids than the rarer non-fluoriferous mineral; a fact which also appears in the action of the gaseous acid upon them. When the two varieties treated side by side with hydrochloric acid, the Edwards ·gopite decomposes much more rapidly than the Burgess L

fter very prolonged ignition the Edwards phlogopite and Port Henry iron mica were still completely decomposable .queous hydrochloric acid. There was, therefore, no split-up of their molecules which could be determined by this hod. The Burgess phlogopite, on the other hand, showed iall amount of change. After eight hours of ignition over blast, treatment with strong hydrochloric acid for three ·, and subsequent leaching with soda solution to remove silica, 2·45 per cent of insoluble residue remained. This, yzed, gave

SiO_2	30·94
R_2O_3	48·06
MgO	19·01
Alkalies	undet.
	98·01

· agrees quite nearly with the formula $MgAl_2SiO_6$, which is composition of a possible member of the clintonite group. ow from the analyses of the micas we get the subjoined ecular ratios; in which titanic oxide is thrown in with the a, the alkalies are united as potash, and only the essential er, stable above 300°, is retained.

	Burgess.	Edwards.	Port Henry.
SiO_2	·668	·751	·609
R_2O_3	·169	·110	·177
RO	·669	·736	·464
K_2O	·116	·098	·094
H_2O	·110	·258	·187
F	·118	....	·018

ence we have the following empirical formulæ:

urgess...... $17R_2O_3 . 67RO . 12K_2O . 11H_2O . 67SiO_2 . 12F.$
dwards...... $11R_2O_3 . 74RO . 10K_2O . 26H_2O . 75SiO_2.$
ort Henry... $18R_2O_3 . 46RO . 9K_2O . 19H_2O . 61SiO_2 . 2F.$

educting oxygen equivalent to the fluorine we have—

Burgess.................. $R'''_{34}R''_{67}K_{24}H_{22}Si_{67}O_{269}F_{12}.$
Edwards................. $R'''_{22}R''_{74}K_{20}H_{52}Si_{75}O_{293}.$
Port Henry............. $R'''_{36}R''_{46}K_{18}H_{38}Si_{61}O_{249}F_2.$

ı all of these micas the silicon and oxygen are present in ost the exact orthosilicate ratio; but in order to discuss the essions further it is necessary to recall the theory of the ı group which has already been cited. Upon that theory, all these salts should be substitution derivatives of normal aluminum orthosilicate, from which the more definite micas develop as follows:

Normal orthosilicate	$Al_4(SiO_4)_3$.
Muscovite	$Al_2(SiO_4)_3KH_2$.
Normal biotite	$Al_2(SiO_4)_3Mg_2R'_2$.
Normal phlogopite	$Al\,(SiO_4)_3Mg_3R'_3$.

Applying these formulæ to the expression given above for the Burgess phlogopite, and regarding the fluorine as present in a group —Mg—F, we have for the composition of that mineral:

$$Al(SiO_4)_3Mg_3KH_2 + Al_2(SiO_4)_3Mg_2K(MgF),$$

the two molecules being mixed in the ratio 1 : 1. Recalculating the original analysis to 100 per cent, uniting TiO_2 with SiO_2, Fe_2O_3 with Al_2O_3, FeO and BaO with MgO, and Na_2O with K_2O, we have this comparison:

	Found.	Calculated.
SiO_2	41·04	41·09
Al_2O_3	17·59	17·46
MgO	27·39	27·39
K_2O	10·62	10·73
H_2O	2·03	2·07
F	2·29	2·17
	100·96	100·91
Less oxygen	·96	·91
	100·00	100·00

The results for the non-fluoriferous phlogopite from Edwards are less satisfactory. Its formula, condensed a little from that given above, is

$$R'''_{22}R''_{74}R'_{72}Si_{75}O_{293},$$

in which the ratio between R''' and Si is 1 : 3·5 nearly. But in this mica, three atoms of magnesia are removable by gaseous HCl, corresponding to 3MgOH. If we assume that this represents a small admixture of a foliated serpentine, and deduct proportionally, there remains

$$Al_{22}Mg_{65}H_{40}K_{20}Si_{69}O_{266},$$

which is very nearly $Al(SiO_4)_3Mg_2KH_2$, or normal phlogopite. At first, as the mineral occurs in a talc mine, we suspected that its anomalies might be due to intermingled talc; but its complete decomposability by hydrochloric acid showed that supposition to be incorrect. If the mica theory is correct, this mineral must contain a small amount of impurity; and a serpentinous or chloritic molecule is the most probable admixture.

In the Port Henry mica the ratios are perfectly simple. The formula, $R'''_{36}R''_{46}K_{18}H_{38}(SiO_4)_{61}O_5F_2$, if we neglect the small amounts of fluorine and excessive oxygen, reduces easily to a mixture of the three typical molecules:

$$Al_2(SiO_4)_3Fe''_2KH,$$
$$Fe'''_2(SiO_4)_3Fe''_2KH,$$
$$Al\ (SiO_4)_3Mg_3KH_2,$$

in the ratio 2:1:1. This compares well with the analysis, reduced as usual, thus:

	Found.	Calculated.
SiO	37·02	37·41
Al_2O_3	13·39	13·34
Fe_2O_3	7·90	8·34
FeO	22·56	22·51
MgO	6·30	6·26
K_2O	9·08	9·79
H_2O	3·75	2·35
	100·00	100·00

Here the theoretical water is too low and the potash too high; both outside the allowable range of error. Their reciprocal replacements explain the slight discordance only in part; and the nature of the mineral suggests a small excess of water due to incipient alteration. Altogether the agreement between analysis and theory is remarkably close.

[To be continued.]

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *On an improved Vapor-density Method.*—The method proposed by SCHALL for determining vapor-density depends upon a comparison of the pressure exerted by a certain known amount of gas let into the bulb and measured under normal conditions, with that exerted by the vapor of the substance itself produced by heating this bulb. Originally a measured volume of air was passed into the bulb; but he has now improved the method by decomposing a weighed quantity of pure sodium carbonate within the apparatus, and then comparing the pressure of the carbon dioxide evolved with that of the vaporized substance. The apparatus consists of a long-necked flask, of 150 to 200cm³. capacity, having a lateral tube near its mouth. This flask is supported within a beaker containing the heating material, by a cork surrounding its neck and resting upon a plate of asbestos, serving as a cover. The lateral tube, which should be 10cm. above the bulb, is con-

nected first to a T tube, and by means of this to a vertical manometer tube 73cm. long and 4 or 5mm. in diameter standing in mercury. The vertical portion of the T tube is attached, by a rubber tube furnished with a pinch-cock, to the evolution tube. This tube is about 12mm. wide for a distance of 5 or 6cm. at its lower end, and is drawn out at the upper to enter the rubber tube. Its lower end is closed by a rubber cork. The neck of the flask is closed above by a rubber tube and a pinch cock, this tube being large enough to contain the glass tube in which the substance to be examined is placed. In making an experiment, the beaker, standing on a metal plate and surrounded with the upper half of a somewhat larger beaker serving to prevent cooling by the external air, is heated until the vapor of the heating material—diphenylamine, for example—fills about two-thirds of its volume. By exhausting the air through the rubber tube attached to the vertical part of the T, the mercury is raised to a considerable height in the manometer tube, the pinch-cock being then closed. If the apparatus is tight, this height will remain constant. The evolution tube, in which has been placed the sodium carbonate contained in a small weighing tube, and also the sulphuric acid necessary to decompose it, is then attached to this rubber tube, the pinch-cock is opened and the height of the mercury in the manometer tube is marked by means of a rubber ring. By inclining the evolution tube the acid comes in contact with the carbonate and evolves carbon dioxide, which depresses the mercury column to a point marked with a second ring. The pinch-cock above the flask is now opened and the substance allowed to fall into the latter. Its vapor produces a still further depression of the mercury, its level being marked with a third ring. Calling the position of the first ring k_6, that of the second k_5, and that of the third k_4, and taking the specific gravity of carbon dioxide to be 1·529, the expression for the vapor-density D becomes

$$D = \frac{s}{s'} \times 3{\cdot}682 \times \frac{k_6 - k_5}{k_5 - k_4}$$

in which s and s' represent the mass of the substance and of the carbon dioxide respectively, and $\frac{k_6 - k_5}{k_5 - k_4}$ the pressure-ratio of the carbon dioxide to the vapor. If s be made equal to s' so that the mass of the sodium carbonate employed is equal to that of the substance, then the simpler expression $D = 3{\cdot}682 \times \frac{k_6 - k_5}{k_5 - k_4}$ may be used, it being necessary only to determine the pressure-ratio of the vapor to that of the carbon dioxide evolved from the same weight of sodium carbonate. Vapor-densities of benzoic acid, napthalene, phenol, aniline, nitrobenzene and benzene determined in this way are given which are quite satisfactory.—*Ber. Berl. Chem. Ges.*, xxiii, 919, Apr., 1890; *J. Chem. Soc.*, lviii, 681, July, 1890.

G. F. B.

2. *On an improved form of Grove's Gas Battery.*—**Mond and Langer** have experimented with the gas battery of Grove with a view of utilizing it commercially. In its improved form it consists of a flat porous diaphragm of non-conducting material having transverse metallic strips let in to its surface at intervals, and covered on both sides with thin platinum foil having 1,500 or more perforations per square centimeter, this foil being covered with platinum black. Several such diaphragms are placed together, with non-conducting frames intervening so as to form chambers, and immersed in dilute sulphuric acid. A current of air is passed through one set of these chambers and a current of hydrogen through the other set alternate with these, so that one side of each diaphragm is exposed to one gas only. The best platinum black for this purpose was obtained by reducing a boiling alkaline solution of platinic chloride with sodium formate; an electromotive force of 0·97 volt being thus obtained. In practice it was found preferable to work the battery at 0·73 volt; in which case a battery having 700 sq. cm. of active surface, covered with 0·35 gram of platinum foil and one gram of platinum black gives a current of 2 to 2·5 amperes. It was observed that no less than half the energy of combustion of the hydrogen is obtained as electrical energy. No material advantage results from the use of pure oxygen and hydrogen over that of air and water gas, the latter obtained by passing steam over red hot coke. The temperature should be maintained constant at 40° by regulating the supply of air.—*Proc. Roy. Soc.*, xlvi, 296; *J. Chem. Soc.*, lviii, 841, Aug., 1890. G. F. B.

3. *On the formation of Hydrogen Peroxide from Ether.*—**Dunstan and Dymond** have studied the conditions under which hydrogen peroxide is formed from ether. They find that contrary to the received opinion, no hydrogen peroxide is formed when properly purified ether is exposed to light under ordinary atmospheric conditions, either in contact with air or water; the results recorded by former observers having been due apparently to the use of impure ether When prepared by the action of sodium ethoxide in excess on ethyl iodide, and exposed to full daylight for five months and to the electric light for two months for three hours nightly, the ether showed no reaction with potassium iodide, hydriodic acid or chromic acid. The ether produced by the action of sulphuric acid on alcohol and purified with sulphuric acid and potash, however, reacted faintly with potassium iodide and decidedly with hydriodic acid but not with chromic acid; while the ether prepared from methylated spirit and exposed to light contained a considerable amount of hydrogen peroxide. The authors have not been able to ascertain the nature of this impurity in the ether, owing to its minute quantity. The impure ether examined by them which was richest in hydrogen peroxide contained only 0·04 per cent of this substance, although it had been for many years exposed to the light. The authors find, however, that ether absorbs the entire molecule of ozone probably, as turpentine does, and on shaking the ether afterward with

water the latter gave with chromic acid the characteristic blue color due to hydrogen peroxide. Moreover, they have proved further that the slow combustion of ether in presence of water produces hydrogen peroxide. A convenient apparatus for the purpose consists of a large flask, containing enough ether to cover the bottom, mixed with an equal quantity of water, and connected with a wash bottle containing cold water. Through the cork of the flask a wide tube passes, open at both ends, and also a spiral of stout platinum wire and a tube bent at right angles which joins it to the wash bottle. By an aspirator connected with this bottle, air is drawn into the flask by the wide tube. Upon heating the spiral to redness and plunging it into the flask, the current of air may be so regulated as to maintain the spiral at a low red heat. Hydrogen peroxide is continuously formed, the flask being from time to time shaken, the ether forming a peroxidized product which is decomposed by the water producing hydrogen peroxide which is dissolved in this water.—*J. Chem. Soc.*, lvii, 574, June, 1890. G. F. B.

4. *On the action of Carbon monoxide upon Metallic Nickel.*—MOND, LANGER and F. QUINCKE have observed that when carbon monoxide is passed over finely divided metallic nickel between 350° and 450° carbon dioxide is evolved and a black powder containing a varying proportion of carbon and nickel is formed; a small quantity of metal being able to decompose a large quantity of carbon monoxide. A sample containing 85 per cent carbon and 15 per cent nickel, when treated with sulphuric acid, gave up about two-thirds of its metal; the remaining carbon being readily attacked by steam, even at 350°, yielding hydrogen and carbon dioxide only. On allowing the nickel to cool while the carbon monoxide was passing over it, it was noticed that the flame of a Bunsen burner into which the excess of gas was conducted, became highly luminous; and on heating the tube between the metal and the outlet a brilliant mirror of metallic nickel was deposited, mixed with a minute quantity of carbon. Further investigation showed that when finely divided nickel, obtained by reducing the oxide at 400° by hydrogen, is allowed to cool in a slow stream of the monoxide, the gas is very readily absorbed as soon as the temperature has fallen to 100°, and a gas is obtained which the authors call nickel-carbon-oxide, in amount about 30 per cent of the escaping gases. This gas at 180° is decomposed into metallic nickel and carbon monoxide again; four volumes of the monoxide being obtained from one of the new gas. Hence it has the composition $Ni(CO)_4$. The gas is not acted on by alkalies or acids. It reduces ammoniacal solutions of cuprous chloride and silver chloride. Chlorine decomposes it with formation of nickel chloride and carbonyl chloride. When cooled in a freezing mixture, the gas condenses to a colorless highly refractive mobile liquid, boiling at 43°, having a specific gravity of 1·3185 at 17° and solidifying at —25° in needle shaped crystals. Since neither cobalt, iron, copper or platinum forms a similar compound, nickel may be readily purified in this way.

And the authors find that nickel thus purified has an atomic mass of 58·58, agreeing well with that of Russell, 58·74.—*J. Chem. Soc.*, lvii, 749, August, 1890. G. F. B.

5. *Waves in air produced by Projectiles.*—MACH and WENTZEL employed photography to study the waves in air produced by the motion of projectiles. In passing through the focus of a photographic lens the projectile caused a discharge from a Leyden jar placed in the axis of the lens, at a distance greater than the point of crossing of the projectile. The illumination produced by the spark served to take an instantaneous photograph of the passage of the projectile. The photograph showed a wave of condensation before the projectile provided that its velocity was more than that of sound. When the velocity was sufficient the wave which preceded the ball had the form of an hyperboloid, of which the summit was in advance of the ball, and the axis of which corresponded to the direction of the ball. There were also traces of conical waves, of which the axes were also in the line of fire and which arose at the base of the ball. Some traces of less distant waves were seen upon denser points of the surface of the ball. All these waves made a less angle with the axis of the projectile than the wave in front. When the velocity was augmented, the angles made by the waves with the line of fire were diminished. When the greatest velocities were attained, the space behind the projectile was filled immediately with little clouds, there was no trace of a vacuum behind the ball even when the velocity was 900 meters per second. The waves produced in the air by the projectile at higher velocities than that of sound progress more rapidly than those due to feeble velocities, so that the compression in front of the projectile is not sufficient to be depicted upon the photograph under the form of waves.—*Revue Scientifique,* Sept. 13, 1890, p. 338.

6. E. MACH and P. SALCHER have extended the method of observation employed by Mach and Wentzel to the study of streams of air blown from various orifices.—*Ann. der Physik und Chemie,* xli, p. 144, 1890.

E. MACH and L. MACH have also employed the method for studying the interference of sound waves of great excursion.—*Ann. der Physik,* xli, p. 141, 1890. J. T.

7. *Re-determination of the Ohm.*—Prof. J. V. JONES read a paper on this subject at the late meeting of the British Association at Leeds. He reviewed the method employed by Lorenz and by Lord Rayleigh, and suggested a direct determination of the mercury unit by this method, instead of the employment of solid conductors by the shunt method and afterwards a comparison with a mercury unit. He points out "if the artificial B. A. unit can be dropped out of one's experiments as well as out of the results, and the measurements made directly on mercury, the simplicity would seem to be a recommendation, and the argument is perhaps enforced by the consideration that there is very nearly as much divergence in the results of different observers for the

specific resistance of mercury in B. A. units as there is in the values obtained for the B. A. unit in absolute measure." The author therefore offered the following:—

(1) That the time is ripe for a new determination of the ohm that shall be final for the practical purposes of the electrical engineer.

(2) That such a determination can be made by the method of Lorenz, the specific resistance of mercury being obtained directly in absolute measure by the differential method described.

(3) That the standard coil should consist of a single layer of wire, the coefficient of mutual induction of the coil and disc, circumference being calculated by the new formula. J. T.

8. *Alternating versus continuous currents in relation to the Human body.*—At the meeting of the British Association held at Leeds, 1890, a paper was presented on this subject by H. NEWMAN LAWRENCE and ARTHUR HARRIES. They arrive at the following conclusions :

A. When the human body, with the skin in its normal unmoistened condition, comes into contact for an appreciable time with base-metal conductors of a dynamo-generated continuous current passing at 100 volts in such a way that the current passes from hand to hand, and the total contact area is about 90 square centimeters:

(1) A current of about 0·016 Ampères will pass through it.

(2) This current can be borne without discomfort for 15 to 30 seconds.

(3) After about 30 seconds unpleasant burning sensations become marked and increase.

(4) The subject is perfectly able to release himself at will during any portion of the time of contact.

B. When the human body comes in contact with dynamo-generated alternating currents, alternating at about 60 to 70 per second under the same conditions as above.

(1) A current of about 0·075 Ampères will pass through it.

(2) This current is *six times greater* than that which produces discomfort.

(3) Instantly the subject is fixed by violent muscular contraction and suffers great pain.

(4) The subject is utterly unable to release himself, but remains exposed to the full vigor of all the current that may be passing.

C. When circuit from electric light or power conductors is accidentally completed through the human body, the danger of serious consequences is many times greater when alternating than when continuous currents are passing at equal voltage, and this is still to a large extent true if the voltage of the continuous current be double that of the alternating.

D. (1) With both forms of current a reduction of contact area materially reduces the amount of current strength that passes.

(2) With the alternating current, if the rate of alternation be reduced below 50 per second, the sensations of pain accompanying muscular fixation will be increased, while if the rate of

ternation be increased, the pain will be diminished. The authors ate in conclusion that mere statements in regard to voltage accompanied by statements in regard to current are highly isleading.—*Electrical Review*, Sept. 12, 1890. J. T.

II. GEOLOGY AND NATURAL HISTORY.

1. *Phylogeny of the Pelecypoda, the Aviculidæ and their lies;* by ROBERT TRACY JACKSON, S.D., Mem. Boston Soc. at. Hist., vol. iv, no. viii, pp. 277–400, pl. xxiii–xxix, 53 figures the text, July, 1890.—Each time a familiar subject is studied om a new standpoint, many novel and interesting results may expected. In the present instance, the author has employed odern and approved scientific methods, and the results, while oth novel and interesting, are of the highest importance to a roper understanding of the pelecypods. The leading method hich is here so fully applied is that of a study of the stages of rowth. The embryology and anatomy are constantly kept in iew and also the chronological history of each group in past eologic time. If all these aspects of growth can be brought to harmony, we have the strongest evidence of the accuracy of ur observations, and most reliable taxonomic data.

Professor Hyatt in his studies of the stages of growth and ecline among the cephalopods has constructed a model, and dicated methods which may be profitably applied to all branches f natural history. These principles have been followed by the uthor, although some particulars have been slightly modified in rder to adapt them directly to the pelecypods. A new term is roposed for a stage of growth between the typembryo of Hyatt, hich as re-defined is characterized in mollusks by a shell gland ith an initial plate-like shell, and the period showing a completed rotoconch. This intermediate period the author terms the *hylembryonic*, or that in which the shell and anatomy are each fficiently differentiated to determine the class to which the rganism belongs.

The important discovery of the characters and relations of the rval or embryonic shell named the *prodissoconch* was briefly escribed in a previous paper by the author, but is here fully eated in its relations and significance in the class. Its existence demonstrated in about thirty genera belonging to widely ffering families of pelecypods, recent and fossil, and is believed indicate a primitive ancestral condition common to the whole ass. The consideration of the oyster and allied forms com-ises one of the leading features. The development of the imal and shell is described and illustrated in over thirty pages d three plates. It is shown that the ostreaform shell is due to e cemented condition of fixation, and on this account is closely mulated in other attached shells, in genera and families which e not closely genetically related. In Pecten, the study of the bits and anatomy at different growth-stages shows the intimate relationships and synchronous variations between the soft and hard parts of the animal. This emphasizes the general truth that the shell is not the mere covering or domicile of the animal, but is a highly specialized enveloping organ, subject to modification from changes in the soft animal within, and to the varying conditions of the environment. From the nuculoid prodissoconch, Pecten passes through stages corresponding to Rhombopteria, Pterinopecten, and Aviculopecten.

A genealogical table for the Aviculidæ and their allies is proposed as a result of these investigations, based upon fossil and recent forms. A nuculoid shell of Lower Silurian type is taken as the radical. The new genus Rhombopteria is proposed for a group of Aviculoids of which *Avicula mira* Barrande is the type. It is considered as the prototype and ancestral form of three distinct branches; one by direct descent through Leptodesma to Avicula, with side branches to Pinna, Perna, Ostrea, Malleus, etc., another doubtful side branch to Pterinea and Ptychopteria, and the third diverging through Pterinopecten and Aviculopecten to Pernopecten, Pecten, Plicatula, Anomia, Placuna, and allied genera. C. E. B.

2. *Revue des travaux de paléontologie végétale, parus en 1888 ou dans le cours des années précédentes;* par le Marquis GASTON DE SAPORTA. Extrait de la Revue générale de Botanique, tome II, Paris, 1890.—This exhaustive review of paleobotanical literature contains much that is original and goes far to settle a large number of the more perplexing problems of the science. The subject is treated by geologic eras, the author's former classification of Paleophytic, Mesophytic, and Neophytic, being employed. As on former occasions he makes the Mesophytic extend so as to include only the Lower Cretaceous, and the Neophytic to begin with the Cenomanian and include the Upper Cretaceous, this being the point in vegetable paleontology where the most distinct line of demarkation occurs. Among the more important points brought out may be mentioned the following: The great difference between the Paleophytic and Mesophytic ferns and those of modern times; the acceptance of the cryptogamic nature of Sigillaria and Calamodendron, so long denied by the French school; the announcement of the discovery of a Lower Cretaceous flora in Portugal containing dicotyledons, and similar to that of the Potomac formation of Virginia; and the surrender of the much discussed problematical organisms called Spirangium or Palæoxyris to the zoologists as of animal nature. L. F. W.

3. *Notes on the Leaves of Liriodendron;* by THEODOR HOLM. Proc. U. S. Nat. Mus., vol. xiii, 1890, pp. 15–35, pl. iv–ix, Washington, 1890.—Mr. Holm is making a study of the germination of plants and of the earlier leaves as they appear following the cotyledons. In this paper he has described and figured a large number of these early leaves of *Liriodendron Tulipifera*, which prove to be very interesting and of special importance to the student of paleobotany, since these early leaves are supposed

to show the stages through which the particular form has passed in its development from earlier times. The genus Liriodendron, as is well known, is a waning type only a single species, or possibly two, remaining in the present flora of the globe, while a large number of fossil species have been described, many of which have leaves which remind us strongly of these embryonic early forms figured by Mr. Holm. As these embryonic forms, however, are not likely to occur in a fossil state, Mr. Holm's contention that there has been an undue multiplication of species by paleobotanists, and that many of the fossil species described are only early forms of living species, is by no means sustained, and he does not seem to understand that these modern embryonic forms are more likely to represent the phylogenetic stages through which the present living species has passed. L. F. W.

4. *Contributions to the Tertiary Fauna of Florida;* by WM. H. DALL. Trans. Wagner Free Institute of Sci., Philadelphia, vol. iii, pt. i, Aug., 1890. 178 pp., 12 plates.—The excellent plan of this series of publications, that of presenting memoirs on the geology and paleontology of Florida, is well exemplified in the present issue. It is aimed to produce a complete monograph of the molluscan fauna of the Caloosahatchie beds, which shall serve as a typical example of an American Tertiary fauna, and as a standard for critical comparisons with other horizons. The present number comprises the greater part of the gastropods, and is to be followed by the second part, to include the remainder of the gastropods, together with the pelecypods and scaphopods. The material employed was collected by Mr. Joseph Willcox, the the author, Mr. Frank Burns of the U. S. G. S., and others.

An important discussion in dynamical evolution, relating to the plications on the columella in the Volutidæ, leads the author to conclude that they are the strongest in those shells having the most deep seated adductor muscles. Also, that the plications are produced by the frequent retraction of the animal, and consequent wrinkling of the large shell-secreting mantle when withdrawn within the shell cone while enclosing the comparatively firm foot and body of the animal. Through an extension of this principle the author also accounts, by similar mechanical reasons, for the teeth and liræ so common and characteristic in many other groups. C. E. B.

5. *On Syringothyris* Winchell, *and its American Species;* by CHARLES SCHUCHERT, from the Ninth Ann. Rept. N. Y. State Geologist. 12 pp. 1890.—The question as to what should constitute the type species of *Spirifer* and *Syringothyris* is discussed by the author, and considerable light thrown on the synonymy of the American species belonging to the latter genus. *Syr. Carteri* Hall is shown to be the same as *Syr. typa* Winchell, and therefore becomes the type. Following Davidson and others *Spirifer striatus* is accepted as the type of Sowerby's genus, although *Syr. cuspidatus* was the first species referred to *Spirifer*. C. E. B.

6. *Mineral Resources of the United States.*—Calendar year 1888, DAVID T. DAY, Chief of Division of Mining Statistics and

Technology. 652 pp. Washington, 1890 (U. S. Geol. Survey, J. W. Powell, Director).—Another volume—the sixth—of this valuable series has appeared, under the able editorship of Mr. David T. Day, and presents the condition of our mining industries for 1888. The volume opens with the usual concise summary for the different metals, etc., and detailed chapters on each subject by individual specialists follow. Some of these chapters are of great fullness and interest as, for example, that in Coal (pp. 168–394) by Charles A. Ashburner. As illustrating the effect of a special demand (in this case, the manufacture of incandescent gas burners) in creating a supply of substances hitherto supposed to be extremely rare, it is interesting to note that during 1887–88, 25 tons of zircon were mined in North Carolina, 4 tons of monazite, 1 ton of allanite, 600 pounds of samarskite and $500 worth of yttrium minerals.

7. *Elements of Crystallography for students of Chemistry, Physics and Mineralogy*, by GEORGE H. WILLIAMS. 250 pp. 12mo. New York, 1890, (Henry Holt & Co.).—The subject of crystallography is often regarded by the student as somewhat repulsive, but to those acquainted with its real simplicity it is obvious that the difficulty is not so much intrinsic as to be found in the way in which it is ordinarily presented. The excellent little volume which Dr. Williams has prepared can hardly fail to do much to remove this reproach and to make the subject thoroughly attractive. The explanations of the morphological relations of crystals are so simple and full and the style so clear that a conscientious student using it will find that the ordinary difficulties disappear while the mastery of the subject will follow as a matter of course. A knowledge of crystals is obviously of importance not only to the mineralogist but also to the chemist and physicist and to the latter class especially this book will be of great assistance.

8. *Rumpfite, a new mineral.*—G. FIRTSCH has given the name Rumpfite, after Prof. J. Rumpf, of Graz, to a mineral allied to the chlorites occurring in aggregates having a fine scaly to granular structure in cavities in magnesite near St. Michael in Upper Syria. It has a greenish-white color; the hardness is 1·5, and the specific gravity 2·675. Before the blowpipe it is infusible. An analysis gave:

SiO_2	Al_2O_3	FeO	MgO	CaO	H_2O
30·75	41·66	1·61	12·09	0·89	13·12=100·12

It was found that practically no water was lost up to 360°, but at a dark red heat 9 per cent went off, while the remainder was expelled at full ignition.—*Ber. Ak. Wien*, xcix, July, 1890.

9. *Polybasite from Colorado.*—Dr. F. M. ENDLICH has identified the rare mineral polybasite at the Yankee Boy mine, Ouray, Colorado. It occurs in tabular crystals, hexagonal in outline, with pyrargyrite in cavities in a quartzose gangue. The determination has been confirmed by Penfield who finds the prismatic angle to be very nearly 60°; Miers gives 60° 10′ as the result of recent observations.

THE

AMERICAN JOURNAL OF SCIENCE

[THIRD SERIES.]

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ART. LIV.—*Long Island Sound in the Quaternary Era, with observations on the Submarine Hudson River Channel;* by JAMES D. DANA. With a map, Plate X.

THE charts of the U. S. Coast and Geodetic Survey have made Long Island Sound and the Atlantic border a means of geological instruction in many ways. The recent issue by the Survey after new soundings, of a chart which admits of convenient photographic reduction, has afforded me the opportunity to illustrate with a map* some conclusions which I deduced from them many years since; and I now take advantage of it in order to sustain or modify the views before presented as the new facts may seem to require. The subjects are: first, The Condition of Long Island Sound in the Glacial period; secondly, The Origin of the channel over the submerged Atlantic border attributed to the flow of the Hudson River during a time of emergence.

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* This map is reduced one-half from the Coast Survey Chart No. 8*a*, entitled "Approaches to New York: Block Island to Cape May; from surveys of 1878 to 1883." The omissions are a southern portion of the chart, the Lighthouses and the information to Navigators on the margin. The additions are Cotidal lines for the Sound, taken from a map published by Prof. Bache, Superintendent of the Coast Survey, in the Report for 1854, and inscribed as prepared by C. A. Schott, of the Coast Survey, from observations by Lieuts. C. H. Davis, and J. R. Goldsborough, U. S. A.; additional bathymetric lines for the Sound, and a strengthening of those over the Atlantic border to make them more readily appreciated; and a few soundings from the larger charts of the Sound and of New York Harbor. The larger charts of the Sound are three in number (Nos. 114, 115, 116), the scale $\frac{1}{80000}$. (They will be found to be of great value in the class room for geological illustration of tidal and sea-shore action.)

The soundings on the map show the depth at mean low tide in fathoms up to 3 fathoms, and in the shallower *dotted* portion in feet.

1. THE CONDITION OF LONG ISLAND SOUND IN THE GLACIAL PERIOD.

1. *The southern of the Sound rivers in the Glacial period.* —In a memoir of 1869, on the "Origin of some of the topographic features of the New Haven Region," (read in September of that year before the Connecticut Academy of Sciences,)* I mention the fact that along the middle third of the Sound, over the larger part of which the depth is 10 to 15½ fathoms, there is *near the southern shore* a channel of 20 to 25 fathoms; and I further point out that this channel ends with strange abruptness about a mile and a half from the shore-line with a depth of 18¾ fathoms, the next soundings beyond being 11½, 10, 9 fathoms. This abrupt termination occurs thirty miles short of the outlet of the Sound, and at a point where the coast-line takes a N. 35° E. course, right in the face of this east-west channel.

It was manifest that this channel could not be due to the scour of the ebb current; for the deepest excavations of the tide occur, as the map shows, at *the narrowings* of the Sound: as for example, south of Norwalk, Conn., where a bank from Eaton's Point, L. I., stretches out nearly half way across the Sound, and occasions an increase of depth from 10–12 fathoms to 32, to return again just beyond to 12 and 13 fathoms; and south of Stratford, where there is a like effect in consequence of shoals; and still more strikingly at the eastern discharge of the Sound, where the depth gradually increases (through the 20 miles of narrowing) from 12–15 fathoms to 50–55 fathoms at the two sluice-ways between Fisher Island and Plum Island,† returning again to 12–18 fathoms in the 20 miles. The trough along the south side of the Sound is deepened at the narrows south of Stratford to 27 fathoms; but it continues on eastward, with a depth exceeding 20 fathoms through the widest part of the Sound and terminates before a narrowing begins. Since the depth to the eastward of the termination is only 9 to 13 fathoms, there is here an abrupt rise in the bottom of 25 feet, and this would have the effect of a dam, and reduce the ebb movement within the trough to a minimum.

In view of these facts, I suggested in 1869 that the south-side channel or trough was the bed of a Sound river in the Glacial period; that the river took the drainage from western Connecticut, Long Island, and the glaciers direct; and that the place of discharge was not by the distant eastern exit of the Sound, but across the narrow north Point of Long Island, in the vicinity of Mattituck, into Peconic Bay.

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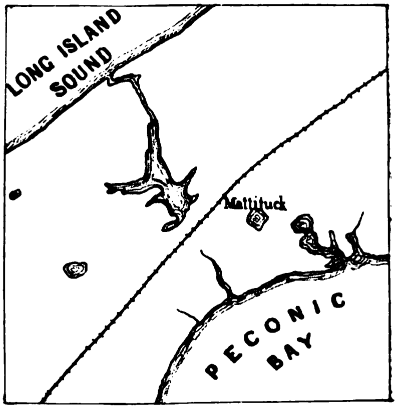
* Trans. Conn. Acad. Sci., ii, pp. 42–112, 1870. An Appendix containing extracts from this paper is annexed to the author's separate copies of his paper on the Phenomena of the Glacial and Champlain periods in the New Haven region. This paper is published in vols. xxvi, xxvii (1883–4) of this Journal, but without the Appendix.

† The deepest areas at these sluice-ways are left blank on the map without the soundings; the depths of the two at the northern sluice-way are 50 and 51 fathoms, of the two at the southern, for the western area 53, 55 fathoms, and for the eastern 52, 54 fathoms.



Near Mattituck, as shown on the accompanying cut, there are inlets both from the Sound and from Peconic Bay which come within 400 yards of one another, and the surface between is but 10 to 15 feet above tide-level. A line of hills occurs along the shores of the Sound either side of the inlet, but they are only 30 or 40 feet high (by the author's estimate). The facts thus appear to favor strongly the conclusion that the Sound river crossed the Point into the Bay. It was not possible without digging or boring to prove that such a channel, free from Cretaceous clays, lay buried beneath the sands, so that the inference is not yet wholly beyond doubt.

2. *A northeastern Sound river.*—As the soundings indicate the waters from the drainage east of New Haven, including those of the Connecticut, passed out of the Sound at its east end.

3. *The southern Sound river-channel cut off from Peconic Bay by depositions of drift.*—Other facts with regard to the soundings throw light on the method by which the discharge into Peconic Bay may have been stopped.

My paper, of 1883, on Glacial phenomena in the New Haven region* points out that the ice of the Connecticut valley trough, or that of the lower part of the great glacier, had the course of this valley for 150 miles (from New Hampshire to New Haven)—this being proved (1) by the abundant glacial scratches over the rocks, and (2) by the fact that the drift stones and bowlders of the valley in its southern part are 99 per cent trap and sandstone, the valley rocks. It was observed further, that the ice, as it was discharged from the confining valley into the open way of the Sound at and west of New Haven Bay, had to make there a turn of 40° to 50° eastward to bring it into conformity of flow with that of the general ice-mass.

* Phenomena of the Glacial and Champlain periods about the mouth of the Connecticut Valley in the New Haven Region, Am. Jour. Sci., xxvi, 341, 1883, xxvii, 113, 1884.

The course of movement in the valley was S. 10°–15° W.; the course outside of it, and that of the upper ice over it, S. 15°–35° E., S. 35° E. being the prevailing course over the higher lands of western Connecticut.

It was stated also, and proved by glacial scratches, that the south-westing which the ice had in the valley continued for 6 to 8 miles west of New Haven, over the Milford region, and was increased there to S. 34° W.; and also that Round Hill, west of New Haven, (R, on the map), an isolated hill 304 feet high and 110 feet deep in bowlder-clay or till, is situated where the greatest crevasses would probably have been made in the wrenched glacier.*

If then this change of course, bringing the bottom-ice in the Connecticut valley into line with the upper ice of the glacier took place over the region from New Haven to Milford, a large deposit of drift, S. 20°–35° E. from there, should be looked for in the Sound. This deposit is there. A line from Milford to Mattituck has the course S. 30° E., or that of the general glacial movement, so that the Milford-New Haven and Northville-Mattituck shore-lines lie in the course of the glacial stream. Now all the way across the Sound between these shore-lines there is shallow water, no soundings exceeding 16 fathoms. *This shallowed region passes by the east extremity of the south-side channel.* The work of deposition was mainly done in the Champlain period, during the melting of the ice, and then, consequently, the southern Sound river of the glacier period had its channel cut off by sand deposits, like so many other streams of the continent.

This course of glacier movement and deposition is shown further to have been a fact by the large quantity of red sandstone—mostly a soft shaly variety—on the shore-hills near Northville, Long Island (north of Riverhead). The surface covered is so extensive that it looked like an outcrop of the Jura-Trias. The facts appear to indicate the position across the Sound of the line of *maximum* transportation.†

This south-side channel, if really that of a river carrying fresh water in the Glacial period, required a more elevated condition than now of Long Island and the Connecticut coast. Evidence of such an elevation—estimated at 100 to 150 feet—was found in the existence of pot-holes at the sea-level in the gneiss or granite off the Connecticut shore, and in the depth at which clay occurs in the stratified drift in the shore deposits of New Haven Bay. Decisive proof is afforded also by the bays of the north side of Long Island, as suggested by Mr. E. Lewis in 1877.* These bays are marvels for size and depth, considering that they have now no sufficient stream to make or keep them open. Their varying courses and complexity of form are unfavorable to the idea that they were made by the shove of the glacier against the unconsolidated sand, gravel and clay-beds of the island—an idea suggested by Mr. F. J. H. Merrill.† The great bay east of Eaton's Neck, called Huntington Bay, has a depth of 50 feet in its southwest part, and of 52 and 58 feet in its inner eastern section called Northport Bay. The bay west of Lloyd's Neck, called Oyster Bay, has a depth, just south of the sand-bank that nearly closes its entrance, of 63 feet, and the inner western portion has soundings of about 50 feet. These equal the greatest depth in New York harbor. The narrow Hempstead Harbor, farther west, has a depth of 30 feet almost at its inner extremity. The depths of these bays have been diminishing since glacial times by the westward tidal drift, which has made shallow entrances, and by the transporting action of waters draining the high sand and gravel hills which border the bay. The most probable explanation of so great size and depth, and of so complex forms for these essentially riverless bays, is that of their excavation by under-glacier streams when the island was enough higher to give the streams the power of cutting; and of cutting not only 50 and 60 feet below the present surface but 60 *plus* the amount of depth lost by subsequent depositions. An increase in height of 100 feet seems therefore to be a reasonable conclusion.

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* A map of the Round Hill region is given on page 358 of the paper, vol. xxvi, 1883.

† On this point see further the paper of this Journal, 1883, xxvi, 355.

But if the northern side bears such evidence of elevation, the southern should afford some corresponding facts. We find such apparently in the south side gravel plain and that at the head of Peconic Bay. This south-side plain is two-thirds as long as the island and nearly half as broad. To the north of a middle east-west line—which is shown on the map, between Jamaica on the west and Shinecock Bay on the east—the land rises to 200 feet and beyond, reaching 384 feet in the most elevated part; and this higher land continues to the northern coast, where the height is mostly 100 to 200 feet; and also westward to Bay Ridge on the northwest coast of the island, on New York Harbor and eastward to Montauk Point, the southeastern cape.

These higher lands have a basis of Cretaceous or Tertiary clays and other strata, which, in some places on the north side of the island, have a height above tide level of 100 feet or more. But the surface is everywhere, though often quite sparsely, sprinkled with bowlders; and below, there is usually a layer 10 to 150 feet thick of bowlder clay or till, which in some parts is very stony, suggesting the idea to E. Lewis, Upham, Chamberlin and others, that the island is the course lengthwise of a part of the continental terminal moraine.

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* Water Courses on Long Island, this Journal, III, xiii, 142.

My own study of Long Island was made in 1875, 1876, and at that time I reached the conclusions here presented.

† Annals N. Y. Acad. Sci., iii, 341, 1886: a valuable paper "on the Geology of Long Island."

But the south-side plain, which slopes from about 100 feet to the sea-level, has no bowlders over it in any part; instead, the material is a fine yellowish gravel nearly or quite to the sea-level, as shown by facts from well-diggings.* The Cretaceous or other clays are cut off short.

The long drainage-area at the head of Peconic Bay also, although having a range of high land and "terminal moraine" both on its north and south sides, and hence lying right in the teeth of the "moraine," has similar characters—yellowish gravel and no bowlders. All the bowlders and stones that dropped over these regions, if there were any—and they may have been as many and as large as elsewhere—are now concealed by the gravel.

The facts may be understood if we regard the drainage area extending westward from the head of Peconic Bay as the course of a large valley occupied by the river which now, in dwindled form, empties into the bay, and that the gravel deposits are Quaternary beds of the Champlain period (that of melting and deposition), laid down over the earlier bowlder deposits. The same explanation will answer also for the region of the south-side plain where the ocean may have made at the time large encroachments and thus chiselled off the Cretaceous or Tertiary beds. Its yellow gravel is post-glacial, notwithstanding its resemblance to New Jersey pre-glacial deposits, color being here, as commonly, of no chronological value.

It is thus rendered probable that during the Glacial period Long Island Sound, instead of being, as it is now, an arm of the ocean twenty miles wide, was for the greater part of its length a narrow channel serving as a common trunk for the many Connecticut and some small Long Island streams, and that the southern Sound river reached the ocean through Peconic Bay. Under these circumstances the supply of fresh water for the Sound river would have been so great that salt water would have barely passed the entrance of the Sound.

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* I am indebted to a recent letter from Mr. E. Lewis (dated Brooklyn, Sept. 11, for the following facts:—

Wells have been dug or bored along the plains—near the old Central R. R.—quite down to tide level. No Cretaceous, or any other deep beds of clay have been found so far as I know. The earth passed through has been sand and gravel in layers down as far as the wells have gone, except here and there some very thin clayey beds, mere crusts which are, I believe, only isolated *pockets*. The Bethpage bed does not extend southward beneath the plain, but northward. The same is true of similar beds at Deer Park, some six miles eastward. These are overlaid with drift. They form the front or southward edge of the hills and occur some 15 feet down at the base of the hills.

During the subsidence of the Champlain period, the Sound gain became an arm of the ocean, and one exceeding somewhat the present in its dimensions. But the existing beaches, outside of the long sea-border bays, could not have been formed before the present level was attained as the Champlain period losed.

2. THE SUBMERGED RIVER CHANNELS.

The map of the Atlantic border off New York and New Jersey in my Manual of Geology, showing by bathymetric ines the course of what had appeared to me to be the submarine channel of the Hudson River over the shallow border of the ocean, first appeared in the first edition of the work, published in 1863, and I refer to it there (p. 441) as proof "that the land was once above the water with the Hudson River occupying the channel on its way to the ocean." On page 544 of the same edition, it is added, that 'the Connecticut River Valley is also distinct over the same submerged pleateau, running southward east of Long Island."

The soundings on which the bathymetric lines affording these deductions were based were those of the Coast Survey Chart of 1852. But the lines on the chart only imperfectly defined the so-called Hudson River channel. A little closer following of the registered soundings brought out the long loops in the lines, and these were inserted in my little map for the Manual, and also in a copy of the chart of the Coast Survey sent at the time to Professor Bache.

Recently, in 1885, the facts bearing on the existence of the submerged Hudson River channel have been presented in this Journal by Mr. A. Lindenkohl, assistant in the U. S. Coast and Geodetic Survey.* The author sustains the conclusion as to the channel and presents others with regard to the "sea-bottom in the approaches to New York Bay," illustrating his paper by a map.

My own further consideration of the facts bearing on the subject leads me now to question some points in the conclusion.

1. THE CONNECTICUT RIVER CHANNEL.—As regards the existence of a submarine Connecticut channel the evidence referred to is certainly unsatisfactory. The bend in the bathymetric lines on the accompanying map between Montauk Point and Block Island looks right for such an origin, and strongly so. But considering the effects of tidal scour during the ebb through the narrow passages of the Sound, briefly referred to above page 426), it is plain that the channel is of this kind. Block

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* Vol. xxix, 475, 1885. The article is entitled "Geology of the Sea-bottom in the Approaches to New York Bay."

Island and Montauk Point stretch out under water far toward one another, and therefore the deepening (see map) from 12 fathoms to 27 and 30 over the narrow interval is a reasonable result for scour. The loops farther south in the bathymetric lines are too broad to be relied on for any conclusion. The channel between Montauk Point and Block Island must have been the course of the northern of the two water-ways of the Sound, if Long Island stood 100 feet or more above its present level in the Glacial period; but tidal scour accounts well for the present condition of the region.

2. THE HUDSON RIVER CHANNEL.—The method of explanation above suggested for the supposed Connecticut River Channel does not meet the case of the supposed Hudson River Channel. But still it may be that tidal scour has had much to do with the present shape also of the latter channel. It may be that the outflowing tide from New York Bay and from the adjoining parts of the shores of Long Island and New Jersey may have combined their forces along a diagonal line crossing the shallow Atlantic border region, and, by scour only, have given the existing depth as well as course to the larger part of the channel. The water, on the ebb, from this inner portion of what Professor Bache named in 1858 the Middle Bay of the American Coast (between Cape Hatteras and Nantucket) move or settle away on more or less oblique courses toward the lowest part of the bottom for escape, and there they flow most rapidly and would erode most energetically.

Effects of inflowing tidal and wind-made currents on depositions.—To appreciate the effect of the ebb on the channel, the work carried on by the inflowing tidal wave and wind-made currents should be in mind. The wave, moving toward New York, the head of the great Middle Bay, gives the sands which the waters take up from the coast and in the shallow waters a corresponding drift or set along the beaches. This drift action on the New Jersey coast is carried on, as was long since shown by Professor Bache, to the extremity of Sandy Hook, at the very entrance to New York Bay; and on the Long Island coast in like manner, as abundantly illustrated by Lieutenant (later Admiral) C. H. Davis, U. S. N.,* it works even to Coney Island, by the north side of the entrance. The course of tidal action in and out, producing the western set of the sands and other materials at the inflow, is well shown by the oblique loops in the bathymetric lines of 10 fathoms, south of western Long Island. Wind-made currents, due to the prevalent eastern storms, work in the same direction, performing much of the transportation.

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* Geological action of the tidal and other currents of the Ocean. by C. H. Davis, A.M., Lieut. U. S. N., Mem. Acad. Arts and Sci., new series, iv, 1849.

For this drift movement on the Long Island coast, sands are ntributed by the high gravel-made bluffs of the seacoast to e eastward, toward Montauk Point, and thus the supply of w material on the Long Island side is larger than on the ew Jersey side, notwithstanding the aid in deposition the ter has from rivers. Accordingly, the work has not only ade the long lines of beaches off the Long Island shores up the New York entrance outside of a series of long bays or unds, but has probably widened the shallow region off the estern part of Long Island, that is, the area under 15 fathoms depth. If so, these drifted sands have been the means of ving the so-called Hudson River channel a shove far toward e New Jersey shore, and also the bend in it just south. In e ebb, the waters from the coast of Long Island and New rsey would carry down shore sands and drop them over the ttom on the way to the channel. The origin of the blue ay or mud of the bottom of the channel, to which Mr. Lin-enkohl draws attention, is not certain. Recent borings on e New Jersey coast at Atlantic City (lat. 39° 20′ N.) reported y L Woolman, reached a depth of 1400 feet without getting elow Miocene.[*] Clay and marl beds occur at intervals, which e nearly continuous below 383 feet.

Description of the channel.—Turning now to the channel, e conditions are found to be, in part, at least, legitimate fects of scour.

The channel may be traced up to the mouth of the "East hannel," the central one of the channels intersecting the sand rs at the mouth of New York harbor. The soundings, 4¼, 8¼, 9 fathoms, lead down from it to the 10-fathom area arked on the map; and this incipient trough has a depth of to 1½ fathoms below the surfaces adjoining.[†] The water rough the Swash and the Main Channels (the two southern) ss into the trough or channel *over its* side instead of by a parate branch channel; and this fact suggests a reason for e channel's leading off from the central East Channel instead the deeper Main Channel: it is more remote from the New rsey coast near by, as well as from the Long Island coast, hence sands drift to the sand-bars with the inflowing tide.

The pitch in the trough or channel from 5 fathoms to the -fathom line, a distance of one and two-thirds mile (statute), s the mean rate of 18 feet a mile; from the same to a depth 15 fathoms, about 5 miles distant, 12 feet a mile; to a depth 20 fathoms, 10 miles distant, 9 feet a mile. The bottom of e channel has thus a continuous but lessening pitch from the

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[*] Proc. Acad. Nat. Sci. Philad., March 25, 1890.

[†] These soundings are given on the Coast Survey Chart of New York Bay, (No. 0). They were inserted on the map for the plate accompanying this paper, but e obscurely copied.

5-fathom area—which is an extended area on the outer side of the sand-bars.

Following the trough outward: from the 20-fathom line to the 30-fathom line, the distance 7½ miles, the mean pitch is 8 feet a mile; and to the 35-fathom line, about 11 miles, it is 8 feet a mile. At the 20-fathom line, the trough is 6 fathoms in depth; at the 35-fathom, it has its maximum depth, 16 to 20 fathoms, that is, 16 to 20 below the level of the bottom outside of it.

At the 35-fathom level the mean pitch outward becomes slight. Through the 24 miles to the 40-fathom level it is *only* 15 *inches a mile*, and there the depth of trough is 13 to 16 fathoms. Then, from the 40-fathom level in the trough the bottom is essentially level for the next 50 miles, three entries of a depth of 41 fathoms being at the end of the 50 miles on the map. A depth of 41 fathoms exists between the first 40 and 42 fathoms registered on the map; and if put in half way between, then the trough is absolutely level for 47½ miles, excepting oscillations within a range of 18 feet in the course of it. So long a level trough is hardly to be found over a continent except in the bed of some tidal stream.

According to the above, the trough has its greatest depth, 80 to 120 feet, where its bottom is 210 to 220 feet below the surface; and this is *at the bathymetric line* of 15 fathoms, so that the deepest part is abreast of the bank having a 15 fathom limit. This depth continues with little diminution until the bathymetric line of 20 fathoms is reached, just beyond which the channel begins its 47½ mile level of 41 fathoms. Abreast of this level it loses gradually its depth by the slope of the general bottom outside of it, until the 40-fathom bathymetric line is reached, where the channel disappears.

Effects of scour.—If the work is that of tidal action the effects of scour decline greatly at the depth in the channel of 210 feet (35 fathoms), and cease entirely at that of 246 (41 fathoms, on the bathymetric line of 20 or 21 fathoms, only 35 miles off the Barnegat beach.

It may be urged that a river channel might vary in like manner; and this cannot be denied. Prof. Bache's map of cotidal lines of 1854 and 1857, shows that the next incoming tidal waves would have reached the outflowing current not far from, if not inside of, the 20-fathom line. And it seems probable that either this has occasioned a cessation of farther deepening by scour, or else the depth alone, as a consequence of passing the limit where the ebbing waters have abrading action. Observations on the currents may give a positive decision of the [illegible]tion.

[illegible]he breadth of the channel, according to the map, is mostly [illegible] 2 miles; so that a cross section of the deeper part would ve a width of 5,000 to 10,000 feet. The best way to realize e truth as to the form and pitch of the channel is to draw agrams with the *actual* proportions; not to refer to an exag- rated and deceiving plaster model.

Terminal part of the Channel, at the margin of the Atlan- -border plateau.—The remaining part of the channel, but miles long, is beyond question the work of river-erosion. nly four miles from the last of the 41-fathom soundings, comes e 52, indicating a mean slope between of about 16½ feet a ile; after the next 2½ miles, comes an 183-fathom sounding, owing a mean pitch off of 315 feet a mile; in 5½ miles more, 277-fathom sounding, corresponding to a pitch of 103 feet a ile; and then to others deepening the gorge a little more owly to 474 fathoms; and this depth exists about in a line ith the 80-fathom bathymetric line. The depth in the cut at is point is hence nearly 2400 feet below the region adjoining. his gorge cannot be pronounced cañon like without more cts from soundings; for the pitch in the sides according to e existing data does not exceed 1:5. Still it affords strong idence of river origin, and, therefore, that *the whole of the annel, up to New York Bay, was once* the course of the udson River. At the same time it makes it strange that the ver channel should have flattened out over the loose sands and uds of the 40-foot to 45-foot level when so tremendous a lunge was before it, unless the conclusion is a right one that dal scour is the cause of *the present features* from the outer mit of the 41-foot level upward to the Bay.

Time of the emergence.—The remarks on the "submerged udson River channel" in my Manual of Geology are intro- uced in the account of the Jura-Trias formation of eastern orth America. The absence of marine fossils from the Jura- rias had led to the inference that the sea-border of the period r some distance out was more or less emerged. It was not ferred that there was then a great elevation of the Conti- ental border—for the large size of the Jura-Trias estuaries roved the contrary to be true; but that there was simply a ending upward and emergence of the coast-region which car- ed the sea-bottom above the water-level out to the 100-fathom ne, or farther. I have referred the emergence to a low anticline begun long before the Carboniferous era, for no arboniferous-Devonian or Upper Silurian rocks of Atlantic- order origin are known. The Hudson River as it left the alisade Estuary (for the region from New York to Tomkin's ove opposite Peekskill, appears to have been part of one of e estuaries) flowed—sluggishly it may have been—across the nerged sea-border, and thence emptied into the Atlantic. It as long after the Jura-Trias period had passed, and even after that of the Lower Cretaceous, that the clays of the Cretaceous series in New Jersey were laid down, and still later, when salt water again reached the present New Jersey shores, so that Cretaceous marine life there abounded.

The above explanation does not account for the great depth of the outer part of the channel; and nothing but a supposition with a *perhaps* can do it. And here is one such. Perhaps when the Jura-Trias beds were nearly completed, the sea-border region over a wider surface continued to rise until the height was sufficient to allow of excavation to a depth of 2500 feet or beyond.

This supposition has these facts in its favor:

(1) The closing part of the Jurassic period and the whole of that of the Lower Cretaceous are unrepresented on this Atlantic border by marine rocks.

(2) The Jura-Trias period ended in a semi-glacial era, as is admitted by all who have studied the beds. The evidence consists in thick deposits of stones and bowlders in which occur masses 2 to 4 feet in diameter, and therefore such as only ice could have handled and transported. They are situated along the western side of the areas in Virginia, Maryland and New Jersey (where the dip of the Jura-Trias beds is eastward) and on the eastern in Connecticut and Massachusetts (where the dip is westward). Fontaine has found in Virginia and Maryland that they are the *later beds* of the formation. Prof. Edward Hitchcock, in his Massachusetts Geological Report (1841), describes the conglomerate as largely developed at Mt. Toby, and at the mouth of Miller's River on the Connecticut, north of Amherst, and as containing many bowlders 3 to 4 feet in diameter; and he refers the conglomerate to "the upper beds" of the Jura-Trias series. At the mouth of Miller's River the piles of stones and bowlders brought down by the glacier of the Glacier period are of like coarseness and character.

In Connecticut similar deposits occur on the east border of the Jura-Trias in East Haven, within three miles of Long Island Sound, as described in this Journal by E. O. Hovey, in 1889; and they contain bowlders of granite, gneiss, trap and other rocks, of various sizes up to two and a half feet in diameter. The source of the granite and gneiss is to the southeastward, but a mile off; and over the two miles beyond to the Sound, there are only low hills and hence no elevations for making ice and glaciers.

The hypothesis suggested above supplies the elevation and is elastic enough to give them whatever height was necessary for the result.

If the time of the sea-border emergence for the formation of a "submerged Hudson River channel," is taken to be that of the Glacial period instead of the Jura-Trias, the query comes up for explanation—Why the eroding river did not cut through the clays, and more deeply trench the sea-border region. It is remarkable that there are no channels or trenches over this border for the Delaware, Chesapeake and other rivers to the south. This appears at first to be proof of no elevation in the Glacial period. It may be good proof of this as regards the southern part of the Atlantic border; but it is incomplete for the more northern, inasmuch as the Glacial deposits of the closing Glacial and the Champlain periods would probably have obliterated through the agency of ice and rivers any trenches that had been previously made.

ART. LV.—*The Preservation and Accumulation of Cross-infertility;* by JOHN T. GULICK.

IN his work on "Darwinism" in a section entitled "The Influence of Natural Selection upon Sterility and Fertility," Mr. Wallace reaches the conclusion that "If it [the cross-infertility] was so closely correlated with physical variations or diverse modes of life as to affect, even in a small degree, a considerable proportion of the individuals of the two forms in definite areas, it would be preserved by natural selection." (p. 178). That the infertility of an incipient species with its nearest allies is often preserved and accumulated, no one can doubt; but there are, it seems to me, very strong reasons for believing that this can never be due to natural selection. Natural selection is the *exclusive* breeding of those best adapted to the environment of the species, through the failure to propagate of those that are less adapted; and the *separate* breeding of those that are equally adapted introduces a wholly different principle. In order to produce the cumulative modification of a variety, selection, whether natural or artificial, must preserve certain forms of an intergenerating stock to the exclusion of other forms of the *same* stock I may select bantams as the object of my attention for a few years, and then excluding them, raise only Shanghai fowls; but this is not the form of selection by which these divergent races were produced. Again, if rats should supplant mice in any country, some persons might call it natural selection, but such natural selection would modify neither rats nor mice. On the other hand if certain variations of mice are better able than the rest to escape their pursuers, they will leave the most numerous offspring, and modification of species will commence. Now if we turn to page 175 of Mr. Wallace's book, we find, that in the illustrative case introduced by him, the commencement of the cross-infertility is in the relations to each other of two portions of the species partially segregated from the rest by occupying a definite part of the general area, and partially segregated from each other by different modes of life. These two physiologically segregated local varieties, being, by the terms of his supposition, better adapted to the environment than the more freely interbreeding forms in the other parts of the general area, increase till they supplant these original forms. Then, in some limited portion of the general area, there arise two still more divergent varieties, with greater mutual infertility, and therefore with still less commingling of the two, and with power to prevail throughout the whole area.*

The process here described, if it takes place, is not modification by natural selection, but a supplanting which does not produce modification, and which does not take place till a new and complicated adjustment has arisen in a portion of the species that is partially segregated, by occupying a definite portion of the area. This new adjustment introduces two new varieties, each with unabated fertility with the other variety; and the process, or principle, by which it is reached receives no explanation in the section we are now considering; but from what he says on page 184, we may judge that his only explanation is an application of the principle of Intensive Segregation, more especially that form of this principle which I have described as the effect of isolation on unstable adjustments, but which Mr. Wallace has rejected as untenable. Moreover, in the supposed case pictured by Mr. Wallace, the principle, by which the two forms are kept from crossing and are preserved as permanently distinct forms, is no other than that which Mr. Romanes and myself have discussed under the terms Physiological Selection and Segregate Fecundity. Not only is Mr. Wallace's exposition of the divergence and the continuance of the same in accord with these principles which he has elsewhere rejected, but his whole exposition is at variance with his own principle, which, in the previous chapter, he vigorously maintains in opposition to my statement that many varieties and species of Sandwich Island land molluscs have arisen while exposed to the same environment in the isolated groves of the successive valleys of the same mountain range. If he adhered to his own theory "The greater infertility between the two forms in one portion of the area"

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* This brief outline of the method by which Mr. Wallace thinks cross-infertility has been produced and accumulated, though given, in another connection, in my article on *Utilitarianism as the Exclusive Theory of Organic Evolution* (this Journal, July, 1890), is here repeated, that the correspondences and divergences in the different theories we are here discussing may be better apprehended.

ıuld be attributed to a difference between the environment
ɜsented in that portion and that presented in the other por-
ns; and the difficulty would be to consistently show how
s greater infertility could continue unabated when the varie-
s thus characterized spread beyond the environment on
ıich the character depends. But, without power to continue,
ɜ process which he describes would not take place. In order
solve the problem of the origin and increase of infertility
tween species he gives up his own theory and adopts not
ly the theory of Physiological Selection but that of Inten-
·e Segregation through Isolation, though he still insists on
lling the process natural selection; for on page 183 he says,
No form of infertility or sterility between the individuals of
ıpecies can be increased by natural selection unless correlated
th some useful variation, while all infertility not so correla-
l has a constant tendency to effect its own elimination."
ʳen this claim he seems to unwittingly abandon when on
ge 184 he says: "The moment it [a species] becomes separa-
l either by geographical or selective isolation, or by diver-
y of station or of habits, then, while each portion must be
pt fertile *inter se*, there is nothing to prevent infertility
ising between the two separated portions."

Mr. Wallace adopts these two fundamental doctrines of the
eory of Divergent Evolution through Segregation, but he
es not apply them exactly as I would. Why, for example,
ould he resort to the supposition that when the two diver-
nt varieties occupying the extensive area are everywhere
mewhat infertile with each other the increase of that charac-
r is gained *only in a limited portion of the area*, and then
reads by conquest? Would it not be simpler, and at the
ne time truer to the facts of nature, to assume, that the
vergent variety can not arise except as it is aided by some
rm of positive segregation, preventing free crossing with the
rent stock; and that in cases where this prevention is only
rtial, any cross-infertility once introduced will diminish the
amping effect of the crossing that occurs, and will *every-
iere* tend to increase, because the majority of each generation
the pure form will be the descendants of those whose cross-
fertility was above the average. There are, moreover, other
rms of negative segregation equally effective with cross-
fertility and Segregate Fecundity. It often occurs that when
gregation with divergence has once begun to show itself, the
riations that are most fully endowed with the new character,
ıough less adapted to the new mode of life than the old
rm is to the old mode of life) will best escape both the severe
mpetition with the rest of the species and the swamping
ect of crossing. In time the pressure for food becomes as

great with the new form as with the old, and escape from competition ceases Under these circumstances either the maladaptation or the infertility of the hybrids will be of the highest importance in preventing swamping. But, is it necessary to suppose, as Mr. Wallace does, that the infertility will disappear in cases where the hybrids are as well adapted as the pure forms? In such cases, during the preliminary period when escape from competition is gained most fully by those most fully segregated, there will naturally be a rapid accumulation of all segregative endowments; but, when that condition ceases, there will still be a sufficient reason for the continuance, or even increase, of the cross-infertility in the fact that more than half of each generation of the pure form will be the descendants of those whose cross-infertility and other segregative endowments are above the average. This principle is one form of what I have called Self-Cumulative Segregation.

This law of self-accumulation does not seem to apply to cross-infertility (or to any other form of negative segregation) that is not associated with positive segregation. Nor is it quite clear that, when unassociated with negative segregation it applies to positively segregating characters (such as social and industrial instincts that lead animals of one kind to pair together, and the prepotency of the pollen of a given kind on the stigma of the same kind securing a similar result for plants). When, however, characters producing positive but incomplete segregation are associated with those producing negative segregation, both classes of characters must tend to increase till the segregation becomes pronounced. As soon as this point is reached, the Reflex Selection, by which the different portions of the species have been kept in harmonious relations with each other, is suspended, and there is nothing but the force of heredity to hold them in correspondence; but the force of heredity, securing this correspondence, has itself been created by the long continued Reflex Selection, and when this is removed, it gradually fails, and divergences of all kinds multiply, increasing the incompatibility of the two forms. Thus arises diversity of habits, diversity of sexual and social instincts, and diversity in the affinities of the male and female elements; and in each respect this diversity tends toward the point of complete incompatibility.

Positive segregation diminishes the amount of crossing, and negative segregation diminishes the swamping effect of crossing when it occurs. Negative segregation may be of the following forms: (1) lack of fertility of first crosses and of the hybrids, which I call Segregate Fecundity; (2) lack of Vigor in hybrids, which I call Segregate Vigor; (3) lack of adapta-

in hybrids, which I call Segregate Adaptation ; (4) lack
scape from competition in hybrids, as compared with pure
ns, which I call Segregate Escape from Competition. Of
se all but the 4th were considered in my paper on "Diver-
t Evolution through Cumulative Segregation," where I
eavored to show that in their coöperation with positive
regation they were parallel factors producing similar results.
w in his supposed case (pp 173-9), Mr. Wallace has treated
Segregate Adaptation, or hybrid maladaptation, as if it
e the effective factor by which the hybrid infertility
lone enabled to increase or even continue. I see no reason
y this should be so. The effectiveness of these negative fac-
s in preserving a species must depend on their being asso-
ed with positive segregation; but the effectiveness of any
of the negative factors is not destroyed by the absence of
others; though Segregate Escape from competition is,
ler ordinary conditions, confined to the preliminary stages
divergence; and may, in certain cases, be the necessary con-
ion leading to the other forms of negative segregation.

Mr. Wallace's criticism of the theory of physiological Selec-
n (pp. 180-3) is unsatisfactory; (1) because he has adopted
fundamental principle of that theory, on pages 173-9, in
t he maintains that without the cross-infertility the incipi-
species there considered would be swamped; (2) because
assumes that physiological selection pertains simply to the
ertility of first crosses, and has nothing to do with the infer-
ty of mongrels and hybrids; (3) because he assumes that
ertility between first crosses is of rare occurrence between
species of the same genus, ignoring the fact that, in many
cies of plants the pollen of the species is prepotent on the
ma of the same species when it has to compete with the
len of other species of the same genus; (4) because he not
ly controverts Mr. Romanes' statement that cross-infertility
en affects "a whole race or strain," but he gratuitously
umes that the theory of Physiological Selection excludes
s "racial incompatibility" which Mr. Romanes maintains
he more probable form, and bases his computation on the
umption that the cross-infertility is not associated with any
m of positive segregation; (5) because he claims to show
t "all infertility not correlated with some useful variation
s a constant tendency to effect its own elimination, while his
nputation only shows that, if the cross-infertility is not
ociated with some form of positive segregation, it will dis-
pear; and (6) because he does not observe that the positive
gregation may be secured by the very form of the physiolo-
al incompatibility. Many species of plants may be pro-
scuously distributed over the same area, and still be com-

pletely segregated by what I have called Potential Segregation. In other words, if the pollen of each species is potent only when falling on the stigma of the same species then the species are completely segregated though growing in the same area. Still further two species may be fairly fertile when artificially crossed, and yet be completely segregated while growing together, through the fact that the pollen of either species when falling on its own stigma will be prepotent over the pollen of the other species even though the alien pollen has fallen upon the stigma considerable earlier. This I have called Prepotential Segregation. Now a variety that is segregated from the parent form by prepotential Segregation and cross-infertility, will neither fail of propagating nor be swamped by crossing though it is indiscriminately mingled with the parent form. In my paper on "Divergent Evolution" I have referred to this special combination of positive and negative segregation, produced by the incompatibility of the male and female elements, and have endeavored to show that when these characters occur together, they tend to increase in intensity according to a law of self-accumulation. (Linn. Soc. Jour. Zool., vol. xx, pp. 239–40, 259–60). Without here entering into any computation, it is evident that the prepotency of the pollen of each kind with its own kind, if only very slight, will prevent cross-fertilization as effectually as a moderate degree of instinctive preference in the case of an animal, and if segregate fecundity, (i. e. cross-infertility) is added it will tend to keep the variety from the swamping effect of the little crossing that occurs, and the variations that are above the average in these characters will have the largest influence on the pure form in each successive generation.

I regard Physiological Segregation as including all kinds of incompatibility between the male and female elements of different groups, whether these groups are varieties of one species, or species of one genus, or species of different genera, or species representing still more divergent groups; and I maintain that the importance of this principle in the origin and continuance of divergent groups, cannot be exaggerated in the case of organisms whose fertilizing elements are freely distributed by wind or water; for in these cases the segregate compatibility and cross incompatibility of the male and female elements may be the means by which the prevention of free crossing is secured, as well as the means by which the swamping effect of the crossing that occurs is prevented. There is, it seems to me, strong reason to believe that this principle is a leading factor in the segregation of multitudes of water animals, as well as in the segregation of species of plants, whether terrestrial or aquatic; and Mr. Romanes has rightly empha-[redacted]ed the importance of investigations in this line.

Concession, Osaka, Japan.

LVI.—*The Deformatin of Iroquois Beach and Birth of Lake Ontario;** by J. W. Spencer.

pon receding from the lake and ascending the high country :h bounds the Ontario basin, an observer is attracted to the derfully plain shore-lines which record the former expan- of the waters. The terraces, beaches, scarps, and spits ss the mouths of valleys clearly represent the deserted es. But they are no longer horizontal lines as when laid n at the level of the former waters. As distinctive fea- s, the beaches were so striking as to attract the attention ie aborigines, who used them as trails across an otherwise, ꞏtimes, muddy country. The early white settlers, in turn, . them as highways and hence we find the "ridge roads" ıt Ontario as well as about the upper lakes. But the recog- ꞏn of the shore-like characters of the raised beaches, by the ꞏ writers,† did not contribute much to the solution of the history.

early fifty years ago, Professor James Hall observed that beaches in New York were not horizontal. But Mr. G. K. ꞏert was the first who surveyed and measured the deforma- of the beaches upon the southern and eastern margins of ꞏ Ontario, and the writer upon the Canadian side of the to beyond Trenton, whence the same beach swings around ırds the north and passes into a broken country. The er has further carried the survey of the same beach about ꞏ miles beyond Watertown, the limit of Mr. Gilbert's rvations.

here are wide-spread remains of old shore-lines at altitudes igh above Lake Ontario, as to indicate that the same sheet ater (Warren water) covered also the basins of the other higher lakes. After the dismemberment of this greater t of water, the surface of that occupying the Ontario-St. rence valley was gradually lowered, and fell several ꞏred feet, without pausing long enough to deeply cut out ꞏraighten its changing shore-lines. At last, this shrinkage he waters came to a pause lasting until the shore-line me more pronounced than that of the modern lake. It is shore-line that forms the basis of the present chapter, constitutes that water-margin which the writer has named

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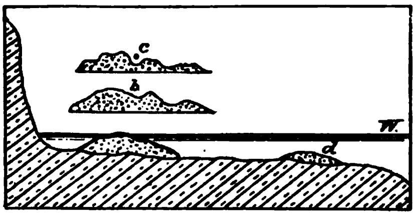
he forerunner of this paper was—"The Iroquois Beach, a chapter in the gical History of Lake Ontario"—was first read before the Philosophical ꞏy of Washington, January, 1888. Proc. Phil. Soc. for 1888, and was subse- ly amplified and published in full in the Transactions of the Royal Society ꞏada for 1889.

or reference to early writers, see "Iroquois Beach," etc., Transactions Royal ꞏy of Canada, 1889, page 121.

the "Iroquois Beach,"* in memory of the aborigines who trailed over its gravel ridges.

The general structure of the ancient shore-lines is somewhat fully described in "Ancient Shores, Boulder Pavements, etc."† but let us here repeat some of the characteristics. Typically, then ancient beach consists of a ridge of gravel and sand rising sometimes to twenty-five feet or more above the frontal plain, which further descends lakeward (as in fig. 1.) Back of the ridge, which rarely exceeds a width of 500 feet, and usually less, with a very narrow crest, there is often a lagoon-like depression. The beach may be broken into a number of ridges (*b* or *c*). The summit marks the height of the wave action. This barrier ridge may become a terrace, or it may pass into the form of a spit across some valley (*h* or *b*, fig. 2). Again the ridge may be wanting, but the shore will be represented as a cut terrace (fig. 3), in front of which a bowlder pavement may frequently be seen (P.) This pavement is also often found in front of gravel beaches. In places where the former waters were gnawing away the drift shores, or where rocky promontories rose out of deep water, true beach structure is wanting, or only represented by benches.

1



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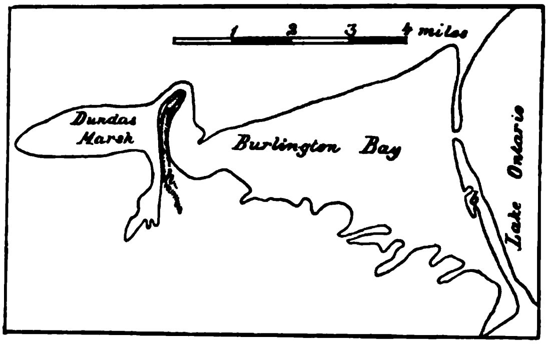

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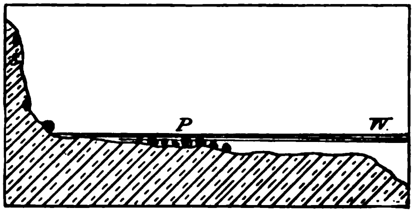

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[*] The name was first printed in Science, Jan. 27th, 1888, p. 49.

[†] By the writer, in Bulletin of the Geological Society of America, vol. i, 1879, p. 71.

In the survey of the Iroquois Beach, the shore-line has been llowed by one or another of its characteristics. even across reas of broken physical features. The altitude of the highest dge, where the beach is broken up into a series of ridges, is at which has been everywhere taken, for it is the one giving ost accurate results. No elevations have been adopted except ose of the summit of the crests (as in fig. 1), or of the spits t *h* or *b*, fig. 2). The measurements consequently represent e maximum height of wave-action, in place of the mean sur-ce of the water, which was a few feet below. The writer's veling has everywhere been done instrumentally.

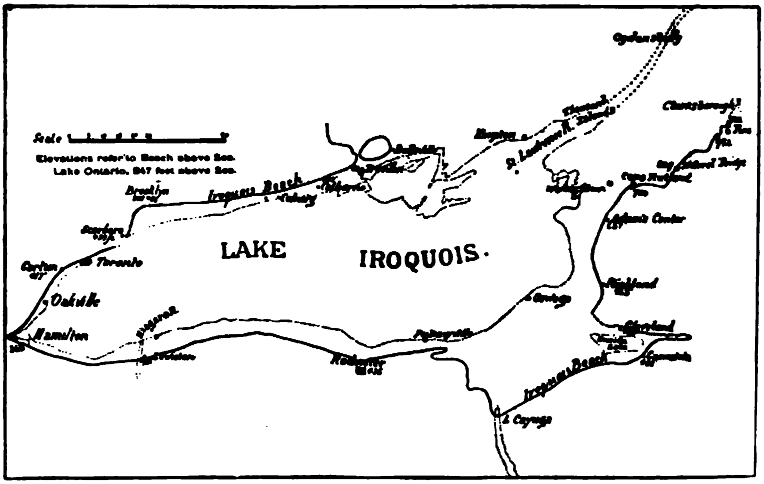
The coast materials, out of which the Iroquois shores have een carved, are mostly bowlder clay, or stratified clays or nds, deposited upon the floor of the lake when the waters ere at higher levels. At a few places the shores rest against aleozoic rocks, in which case the materials of the gravel beach e more scanty, as the pebbles were mostly derived from the ony drift, or there may be an absence of the beach.

Except in spits across old valleys, the thickness of the sand d gravel of the beach does not usually exceed 20 feet, but in ont of valleys it may reach a thickness of 100 feet (*h*, fig. 2). he internal structure always shows stratification, with such ping and false-bedding as are characteristic of beaches.

There are frequent exposures which show that the Iroquois each rests upon stratified stoneless clay—the silt washed into e waters when the waves were encroaching upon older and gher shore-lines, and assorting the bowlder clay, which, at e higher elevations, formed the coast. Eastward of Water-wn, the beach rests upon stratified sand in place of clay, as ere was but little stony clay in the drift to furnish silt for the der lake floor.

From near Trenton to the head of the lake, and thence ound the southern and eastern borders to near Watertown, e Iroquois Beach is not hard to follow; but eastward of that int the features are more complex. The old coast of stony ay is there replaced by stony drift sand, and hence there is t little lithological distinction between the frontal plain and e older sandy drift shores. Moreover, such a coast is apt to defaced by the sand being heaped into dunes. Again, in e region beyond Watertown, the Iroquois Beach is inter-pted by promontories of Paleozoic limestones and shales, sing out of deep water, upon which at most only benches ere cut. Farther, northeastward, the beaches trend among ld headlands and islands of crystalline rocks. Wave action, hich carves broad terraces out of drift materials, can cut only oderately well-marked benches out of limestones. But when e same intensity of wave force is applied to hard crystalline rocks, especially when interrupted by islands, the benches become less conspicuous than when excavated out of limestones, or they may become very obscure. Still, upon the flanks of the Adirondack Mountains, the Iroquois Beach can be followed and identified by the remains of barrier ridges, terraces, bowlder-pavements, benches, and above all by the occurrence of spits across old valleys.

Combining the surveys of Mr. Gilbert and the writer, the position of the Iroquois Beach is shown on the accompanying map.



The following table gives the elevation at salient points along the Iroquois Beach. The elevations given are those of

	Feet above the sea.	
Lake Ontario, surface of	247	(U. S. Lake Survey)
Hamilton	363	(Spencer).
Burlington Heights	355	"
Waterdown Station	365	"
Cooksville Station, about	400	"
Carlton Station	417	"
Kingston Road, crossing railway 12 miles east of Toronto,	459	"
Whitby, 6 miles north of lake, near	507	"
Colborne Station, 2 miles north of	602	"
Trenton Station, 2½ miles north of	682	"
Lewiston, N. Y.	385	(Gilbert).
Rochester, "	436	"
Canastota, "	441	"
Cleveland, "	484	"
Constantia, "	489	"
Richland, "	563	"
Adams Centre	657	"
Prospect Farm, 4 miles east of Watertown	730	(Spencer).
Natural Bridge	829	"
East Pitcairn, one mile northeast of	942	"
Fine	972	"

crest of the highest ridge, where the beach is broken into umber of ridgelets, having sometimes a vertical range of nty-five feet or more.

'hus we see that the Iroquois Beach has been deformed to extent of 609 feet, between the western end of Lake tario and Fine, of which only 78 feet of rise occurs upon southern side of the present lake, while the great propor- ı of the uplift is found west and northwest of the Adiron- k Mountains. Upon the northern side of the lake, the ern equivalent of uplift is more pronounced. At the tern end of the lake, the mean maximum uplift is 1·60 feet mile in a direction of N. 28° E. This rate increases to- ·ds the northeast. To give a mean rate of rise, at the eastern of the lake, does not convey a correct idea, for the uplift reases in a progressive ratio. Thus in the region of Oneida e, the uplift is 3·5 feet per mile, while in the region of tertown it amounts to 5 feet per mile; and farther north- ward the deformation reaches 6 feet per mile, in the direc- ı of N. 60° E. This seems an extraordinary amount of asurable terrestrial movement, but the records are inscribed he beach. It is not yet known where this upward move- nt ceases.

Jpon the Erie beaches, outside of the Ontario basin, Mr. bert found a considerable amount of warping recorded at ttenden, N. Y., over the horizon at the western end of the ie lake. I have traced the Erie beaches around to the theastern side of Lake Michigan. Combining our results, I l the measured uplift between the two regions amounts 324 feet. But the beach, where last observed near Lake chigan, is 45 feet above its surface. Indeed, it is there diffi- t to trace, owing to the druny character of the sandy country. the assistance of other beaches found in that region, the clusion is readily arrived at that the shore-line under con- eration must pass from 40 to 60 feet beneath the waters of lake at Chicago. It is then evident that the terrestrial lift, between Chicago and Crittenden, amounts to not less n 410 feet. Crittenden is nearly on the line of strike of the quois beach (S. 62° E.), at its lowest point, with Hamilton. e Erie beaches, eastward of the Niagara River, were de- med to the extent of 0·4 feet per mile before the Iroquois sode, the remainder of their uplift having been synchronous h that in the Ontario basin. But the pre-Iroquois differ- ial uplift of the beaches farther west is reduced to almost o, for the beaches south and west of Lake Erie have suffered y little deformation. Consequently a sufficient amount of ormation of the beaches has been measured to allow for inac- acies when we take the elevation of the Iroquois Beach above the sea level (363 feet), as the amount of movement that must be added to the Iroquois plain in order to represent the terrestrial uplift of the Ontario basin since the Iroquois shore was formed. Therefore, it is apparent that *the great Iroquois Beach was constructed approximately at sea level.* The total amount of uplift since the episode will then be the height of the beach, at any place, measured above the sea level, which, at Fine, is 972 feet.

Were the Erie beaches recognizable in the Adirondack wilderness near Fine, they would be found at altitudes of 1600 feet and more above the sea. But this is a calculation outside of our subject, which is based upon measurements.

The terrestrial movements recorded in the beaches have not been those of subsidence towards the west, but of uplift towards the east, in the same direction as those changes which have left unquestioned marine remains deposited at high altitudes in the St. Lawrence valley.

One focus of the warping about the western end of Lake Ontario and about Georgian Bay appears to have been in the region of lat. 48° N., long. 76° W. Another focus of uplift is somewhere beyond the last point of rise measured in the Adirondacks. Thus the axis between these foci appears to coincide, more or less, with the old Archæan axis of the continent, as suggested by Professor Dana.

The uplift of the Iroquois Beach has been since the episode of the uppermost deposits of drift or till, for higher and older beaches than the Iroquois rest upon the newest stony clays of Ontario, Michigan and other slates. The Iroquois Beach rests upon the mud floors of the earlier sheets of water which covered the till deposits. The rate of northeastward regional uplift has been gradually diminishing, for we find other beaches, lower than the Iroquois, whose rate of rise is much reduced below that of the great beach. But the Iroquois plain was the great event in the history of the Ontario basin.

In the rising of the land, after the Iroquois episode, there were pauses, but not of such duration as to permit of the formation of great shore-lines like that just described. After the waters had fallen about two hundred feet below the Iroquois plain, there was a conspicuous rest. This is recorded in a terrace near Watertown at 535 feet above the sea. At Oswego, we find a beach descending to near water level, at about 185 feet below the great Iroquois beach. Farther westward, it passes below the lake. The dip of the Iroquois Beach, between the region of Oswego and the western end of the lake, is about 78 feet; and accordingly we should find the remains of this younger shore-line (for a large proportion of the regional uplift has been effected since its formation) submerged

65 or 70 feet at the western end of the lake. Behind the odern bars and beaches, the water of Irondiquois Bay (a urrow river-like channel) is 78 feet deep; the Niagara River, feet; and Burlington Bay, 78 feet. These conditions indi-ite that the lake covering these channels was at one time ithdrawn, leaving only a few feet of water in the rivers hich flowed through the otherwise dry valleys. Here, then, front of the bays, submerged or buried by more recent accu-ulations (upon re-submergence), is the position of this lower ach extending westward of Oswego, which was formed at a vel now 70 feet below the surface of the western end of the ke. Indeed, the uniformly narrow Burlington Beach (*b*, fig. , with a length of five miles across the end of Lake Ontario, thus easily explained as having originated as a small barrier, front of the shallow river, flowing down the Dundas valley d across the now submerged floor of Burlington Bay. With e more recent backing of the waters of the lake, this bar ew to the proportions of the modern beach, built out of aterials derived from the older shores and not from river eposits.

At the time when this young beach—now beneath the lake -was being formed, the waters had receded for only from ree to five miles from what are now the western shores of ntario, but they extended farther landward than at present on its northern side, as shown by the raised beaches, and by e absence of submerged channels.

The Niagara River was about three miles longer than now, itting its way over a projecting point of shaly rocks. But is channel is at present filled, and is again further submerged neath the lake.

During the continued rise, the waters of the Ontario basin ay have been even somewhat further shrunken at its western d, and the waves may have moulded some of the submerged carpments upon the southern side. The waters upon the uthern side could have nowhere been more than about 200 et below the present level, even if that amount of shrinkage, hich represents most of the barrier holding the basin above e sea, ever obtained. However, no important geographical ent is recorded in any of the possible coast-lines submerged levels below that just described.

With the regional uplift, the barrier across the St. Lawrence lley eventually cut off free communication with the sea, at a mmon level. This uplift has continued until the Iroquois each now rests at 972 feet above the sea at Fine, and the odern lake at 247 feet. *Thus the modern lake had its birth.* his warping at the northeastern end of the lake, during the ter and since the Pleistocene period, has been enough not only to account for the rocky barrier holding the lake above the sea, but to account for all of the barrier across the St. Lawrence valley closing the ancient basin of Ontario to a depth of nearly 500 feet below sea level.*

In the Iroquois Beach no shells have been found. Only the remains of mammoth, elk and beaver have been met with.† Consequently, the question arises as to the freshness of the waters. Not far from the eastern end of Lake Ontario, the remains of a whale were found at 450 feet above the sea—at an elevation which would admit of the free access of oceanic waters into the Ontario basin.‡ Still no other marine or fresh-water fossils have been found in the beaches. It therefore appears to me that the absence of such organisms speaks no more in favor of fresh water conditions than of brackish or even salt when the Iroquois shores were being formed; and does not preclude the idea of free communications with the sea any more than when the whale came landward in waters 200 feet higher than the present lake surface. Indeed, I look upon the Ontario-St. Lawrence valley, during the Iroquois episode, as resembling the Gulf of Obi, which is a sheet of water from 40 to 60 miles wide, and 600 to 700 miles long, into which so much fresh water is discharging as to render even the Arctic Sea for sixty miles beyond the mouth of the gulf so fresh as to be almost potable,§ and sufficiently fresh to destroy marine life.

The only dam that has been hypothecated as filling the St. Lawrence valley is that of a glacier. As the Iroquois Beach was at sea level, no dam ought to be required to hold up the water, but at most only to keep out the sea. However, I have followed the beach for sixty miles within the margin of the hypothecated barrier without finding the traces of an ending of the old shore markings upon the confines of the Adirondack wilderness. Even the coincidence of the shallow and small channel, discovered by Mr. Gilbert, connecting the Iroquois waters with the sea, by the Mohawk valley, or of the broader and lower valley of Lake Champlain, does not prove the necessity of a former barrier across the St. Lawrence valley any more than the narrow channels among the gigantic islands north of Hudson Bay would prove the former presence of a dam holding in the waters of that bay, were the whole country elevated. For a glacial dam to exist across the Adirondacks, even narrowest point, it would need to be 50 or 60 miles wide. had no greater depth than the water north of Fine used to the ice would need to be thick enough to fill a channel 0 feet. But as the differential uplift probably continues ghout the Adirondack region, we would need to be pre- to accept a dam of at least 1300 feet in thickness, and a red miles across. Apparent beaches in Vermont at 2100 bove the sea (Hitchcock),[*] and the Post-Pleistocene emer- of Mt. Desert, observed in the coastal markings to its nit of 1500 feet (Shaler),[†] increase the probability of our nal uplift continuing throughout the Adirondacks.

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* See Origin of the Basins of the Great Lakes, by J. W. Spencer, Q. J. G. S., vol. xlvi, Part 4. 1890.

† Col. C. C. Grant of Hamilton has recently found other vertebrate remains, but not yet determined.

‡ Sir W. Dawson. Can. Nat., vol. x, p. 385. The remains are in the Redpath Museum at Montreal.

§ Nordenskjöld in "Voyage of the Vega," p. 140.

y water-proof dam in front of the Iroquois Beach would had to endure throughout the long period of its forma- But all known glacial dams are small and evanescent. the one suggested as closing up the Ontario's basin would had to restrain a greater sheet of open water than that of rn Lake Ontario, receiving not merely the waters of the upper lakes, but also those of the melting of the hypothe- glacial dam. It is questionable what thickness of ice d hold in the waters, for the modern glacial dams of Mt. lias discharge beneath 500 feet of ice for a distance of miles.[‡] As soon as the waters fell below the Mohawk t, the discharge of the glacial lake ought to have melted owered the ice on the one side and carved out terraces on ther, unless the river were 50 to 100 miles wide. And there erraces upon the northern side of the Ottawa valley, as as upon the flanks of the Adirondacks.

ere seem to me to be no phenomena in the later lake ry of Ontario necessitating the existence of a dam across St. Lawrence valley. In short, the Iroquois water was a The Adirondacks and New England formed great ds. The Iroquois episode commenced almost synchronous the birth of the Niagara Falls. And the history of Lake rio records interesting and great changes which now form ple story.

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[*] Geology of Vermont.

[†] Geology of Mt. Desert. Eighth Annual Report of U. S. Geol. Survey.

[‡] Harold Topham in Proc. Roy. Geog. Soc., 1889, p. 424.

ART. LVII.—*Experiments upon the Constitution of the Natural Silicates*; by F. W. CLARKE and E. A. SCHNEIDER.

[Continued from p. 415.]

6. *The Vermiculites.*

Of this interesting group two examples were studied; the well-known, typical jefferisite from Westchester, Pennsylvania, and the kerrite from near Franklin, Macon County, North Carolina. The latter, presented to us by Prof. F. A. Genth, was part of his original sample, and the analysis agrees well with Chatard's. Analyses as follows, on *air-dried* material.

	Jefferisite.	Kerrite.
SiO_2	34·20	38·13
Al_2O_3	16·58	11·22
Fe_2O_3	7·41	2·28
FeO	1·13	·18
NiO	----	·48
CoO	----	trace
MgO	20·41	27·39
H_2O (ignition)	21·14	20·47
	100·87	100·15
H_2O over H_2SO_4	10·56	9·62
H_2O at 105°	----	·24
H_2O at 250°–300°	4·20	4·10
H_2O at red heat	6·18	6·27
H_2O at white heat	·20	24

Here the water falls into three sharply defined parts; one, lost by drying over sulphuric acid, very loosely held; a second, water of crystallization, lost below 300°; and the third, constitutional water.

By dry hydrochloric acid gas the minerals were little affected. The data are as follows, for 383°–412.°

	Jefferisite.	Kerrite.
Hours heated	32	32
MgO removed	3·98	3·15
R_2O_3 removed	1·38	·09

By aqueous hydrochloric acid both of the vermiculites were easily and completely decomposed. By ignition, however, with fusion in the case of the kerrite, they were split up into soluble and insoluble portions. In the kerrite, after fusion, only 10·64 per cent of magnesia and 3·75 of sesquioxides were removable by aqueous hydrochloric acid, but nothing more could be determined for want of material. The jefferisite, after strong ignition, and subsequent digestion with the acid three days, gave 51·08 per cent of insoluble residue. From s, soda solution extracted 21·54 of silica, leaving 29·54 per it of an undecomposed silicate. This, analyzed independly, contained

SiO_2	45·08
Al_2O_3	22·82
Fe_2O_3	10·01
MgO	21·48
	99·39

ence the ratios $SiO_2:R_2O_3:MgO=75:29:54$; which correond nearly to a mixture of Al_2SiO_5 with $Mg_2Si_2O_6$. As to e real nature of this residue, we can only offer the foregoing ggestion as a plausibility. Positive knowledge is lacking. ne vermiculites, however, are alteration derivatives of the icas; and by their metamorphosis kyanite, fibrolite, or andasite may be generated naturally. Geologically, the suggesn is worthy of consideration.

Now, from the two analyses we get the subjoined molecular tios.

	Jefferisite.	Kerrite.
SiO_2	·570	·635
R_2O_3	·209	·124
RO	·526	·694
H_2O, over H_2SO_4	·587	·524
H_2O, 250°–300°	·233	·226
H_2O, constitutional	·355	·363

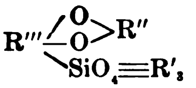
ence the empirical formulæ

Jefferisite............ $R'''_{42}R''_{53}H_{70}Si_{57}O_{266}+82H_2O$
Kerrite............... $R'''_{24}R''_{69}H_{12}Si_{63}O_{267}+75H_2O$

From the jefferisite gaseous hydrochloric acid removed 10 ms of magnesia, and from the kerrite 8 atoms. Taking is, hypothetically, as MgOH, we have

Jefferisite.... $R'''_{42}R''_{43}(MgOH)_{10}H_{60}(SiO_4)_{57}O_{27}+82H_2O$
Kerrite...... $R'''_{24}R''_{61}(MgOH)_8H_{64}(SiO_4)_{63}O_7+75H_2O$

The small excess of oxygen in these expressions needs to be counted for. To regard it as forming the group AlO, hower, is impracticable; for then the residual aluminum atoms uld be less than one-third the silicic groups, which is inadissible under the mica theory. The simplest interpretation as follows: In the clintonite group the general formula



$$R'''\begin{cases} O \\ O \end{cases}\!\!>R'' \quad R'''\!-\!SiO_4\equiv R'_3$$

ems to apply. If we treat the excess of oxygen in the two rmiculites as pertaining to molecules of this order, the composition of both minerals reduces to very simple terms; one term being a normal hydro-mica. In the jefferisite we have approximately $AlO_2MgSiO_4R'_3.3H_2O+Al_2(SiO_4)_3Mg_3H_3.3H_2O$; or a mixture in equal ratios of a hydro-clintonite and a hydro-biotite, the alkalies being replaced by hydrogen, and R′ being in part, about one-third, MgOH. The greatest uncertainty is in the loosely combined water, which is probably analogous to the water in laumontite. Two-thirds of the $3H_2O$ is of this type; the remaining one molecule being given off below 300°. Dried at 100° the salts become monohydrated. Reducing the bases of the analysis to terms of alumina and magnesia we get the following comparison with the formula:

	Found.	Calculated.
SiO_2	34·97	34·00
Al_2O_3	21·91	21·67
MgO	21·51	22·67
H_2O constitutional	6·52	6·37
H_2O, 250°–300°	4·30	5·10
H_2O, over H_2SO_4	10·79	10·19
	100·00	100·00

The concordance here is less perfect than in the previous cases, but for obvious reasons. First, the uncertainty in the water has already been mentioned. Secondly, the actual ratio between the clintonite and biotite molecules, as deduced from the empirical formula, is not 1 : 1 but 13 : 15. Finally the observed MgOH is a little less than one-third R'_3. Still, considering the character of the mineral, the agreement between analysis and theory is as close as could be expected.

For kerrite, uniting the univalent factors, the formula becomes

$$R'''_{24}R''_{61}R'_{72}(SiO_4)_{63}O_7\,.\,75H_2O$$

This, very nearly, is equivalent to

$$AlO_2MgSiO_4R'_3\,.\,3H_2O+Al(SiO_4)_3Mg_3H_3\,.\,3H_2O,$$

commingled in the ratio of 1 : 5, with two-thirds of R'_3 being MgOH. The second term in this mixture is a hydrous phlogo-

	Found.	Calculated. As given.	 As a phlogopite.
SiO_2	38·51	38·33	41·66
Al_2O_3	12·79	12·38	11·84
MgO	28·02	29·12	27·77
H_2O, constitutional	6·61	6·55	6·25
H_2O, at 250°–300°	4·35	4·37	4·16
H_2O, over H_2SO_4	9·72	8·75	8·32
	100·00	100·00	100·00

pite; and here again we have trihydration, with two molecules of water loosely held and the third more firmly combined. In this case we may compare the analysis, reduced to alumino-magnesian form and 100 per cent, both with the formula given above and with that of the hydrous phlogopite taken separately.

This comparison, which is in the main satisfactory, makes it perfectly clear that kerrite is essentially a trihydrated phlogopite, with the alkalies replaced by hydrogen. The analogies between kerrite and jefferisite are perfectly clear, and both minerals become monohydrated by exposure over sulphuric acid. It is our intention to examine several other vermiculites in the near future, and we believe that all of them will be easy to interpret with the aid of the evidence already gained.

Final considerations.—In the foregoing pages we have shown conclusively that gaseous and aqueous hydrochloric acid differ widely in their action upon magnesian silicates. We have also endeavored to show that in this group of minerals, the gaseous acid attacks only that part of the magnesium which is present as the univalent group —Mg—OH; and although the proof is far from complete, the evidence in favor of our view appears to be cumulative. In the first place olivine, which cannot contain hydroxyl, is almost unattacked by the gas in the range of temperatures studied. Secondly, serpentine, which must contain MgOH, is attacked proportionally to the excess of oxygen over the ortho-silicate ratio. The results, to be sure, are only approximations to quantitative accuracy, but they are uniform enough to warrant our conclusion. Finally, ripidolite behaves like serpentine, and gives an analogous formula; while the micas, which presumably contain little or no hydroxylated magnesia, are but slightly affected. All the evidence, so far, converges to the one conclusion; which has at least the status of a legitimate working hypothesis. All the hydrous silicates so far examined are not alike in their behavior towards the reagent, but only those are attacked by it in which there are strong reasons for assuming the presence of the basic MgOH.

In the course of the investigation certain collateral questions have arisen which have been the subject of experiment. For instance, in the action of gaseous hydrochloric acid upon silicates may not insoluble oxychlorides be formed, which would escape notice in the analysis of the soluble portion? To answer this question the residues were in several cases examined, and found to be practically free from chlorine. Traces only of chlorine were retained, insufficient to modify our ratios. Furthermore, precipitated and ignited magnesium oxide, heated at 498°–527° in gaseous hydrochloric acid was almost quantitatively converted into chloride, showing the stability of the latter in a stream of the dry gas. 94·13 per cent of the required chlorine was taken up by the oxide, so that the possible formation of oxychlorides in our experiments may be fairly left out of account.

Similar experiments with brucite, however, gave apparently anomalous results. The mineral examined was typical material from Texas, Lancaster County, Pennsylvania, which was first analyzed and subjected to dehydration estimations. The data are as follows:

MgO	67·97
FeO	undet.
MnO	·97
Fe_2O_3	·39
H_2O	30·81
	100·14

Water lost at 105°	·18
" " 250°	·46
" " 383°–412°, 2 hours,	7·57
" " " 3 " more	19·37
" " " 2 " "	·06
" " 498°–527°, 1 "	·23
" " " 1 " more	none
" " full ignition	2·94

The greater part of the water, therefore, nine-tenths of it, is lost at about 400° C., but is given off somewhat slowly.

Heated for 28 hours to 383°–412° in dry hydrochloric acid gas, constant weight was not attained; but at this point the experiment was stopped, and only 10·33 per cent of the magnesia had been converted into chloride, or a little less than one-seventh of the total amount. Several other experiments, at temperatures ranging from 200° to 500° gave similar results, all low, and in no case was more than one-fifth of the required chlorine absorbed. At the higher temperature, 498° to 527°, the reaction went farthest, and the absorption of chlorine was still going on at a very slow rate. In this case, the brucite must have become almost dehydrated; but the oxide so formed was different in its behavior from the precipitated oxide previously examined. The difference may have been due to physical causes, such as a different degree of compactness in the material; but it is doubtful whether that supposition would fully account for the anomaly. Probably magnesium hydroxide, like other hydroxides investigated by Carnelley and Walker,* undergoes progressive dehydration through a series of stages; each step being attended by a polymerization of the residue. An oxide so formed might coneivably be more stable than the oxide with which we previously worked; at all events, the two are not necessarily dentical. As regards the bearing of these data upon our ilicate work, we can hardly offer satisfactory conclusions. Still, magnesium saturated by hydroxyl is quite differently ombined from magnesium which is but half saturated with hat radicle, and in the mixed union in a silicate, the polymeriation attending dehydration above referred to could hardly ccur. We are inclined to believe, on the whole, that MgOH n a silicate has a lower order of stability towards gaseous HCl han the compound $Mg(OH)_2$; but this point remains to be roved. We hope to continue this investigation among other ilicates; and we feel confident that the data so far obtained ave value quite independently of our conclusions.

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* Jour. Chem. Soc., liii, p. 59, 1888.

Laboratory U. S. Geological Survey, Washington, July 7, 1890.

ART. LVIII.—*Eudialyte and Eucolite, from Magnet Cove, Arkansas;* by J. FRANCIS WILLIAMS.

[By permission of the Geological Survey of Arkansas.]

Eudialyte.—As long ago as 1861 Professor C. U. Shepard[*] iscovered small nodules of a brilliant crimson mineral in the eldspar of the elæolite rock of Magnet Cove, Arkansas. He t first supposed this mineral to be corundum, but after testing its hardness (which he found to be less than 6·), and bserving that it gelatinized with hydrochloric acid, he decided hat it was eudialyte. From that time the occurrence of this mineral in Arkansas has been mentioned in most text-books of mineralogy[†] on Professor Shepard's authority, but not until ery lately has the subject been revived. During the last ear William J. Kimzey of Magnet Cove has found a number f good crystals and also a considerable quantity of the nodular material. Hidden and Mackintosh have published a note in his Journal,[‡] in which they describe this nodular, rose-red, early transparent mineral, and state that it is probably eudialyte, and identical with that discovered by Shepard.

During a recent visit to Magnet Cove, in the interest of the Geological Survey of Arkansas, I was fortunate enough to obtain some very good specimens of this rare mineral, several of which were well adapted for crystallographic measurement. Through the kindness of Messrs. W. E. Hidden of New York and C. S. Bement of Philadelphia, I was enabled to measure two other crystals from this locality, which were especially interesting.

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[*] This Journal, II, xxxvii. 405, 1864.

[†] System of Mineralogy, J D. Dana. 5th edition, p. 249. Lehrbuch der Mineralogie, G Tschermak. 2d edition, p. 522. Elemente der Mineralogie, Naumann-Zirkel 12th edition, p. 745. etc.

[‡] Am. Jour of Sci. III, vol. xxxviii, 494, 1889.

The crystals that I have seen from this region range from 3 to 18^{mm} in diameter and are, for the most part, thick tabular parallel to the base. They are transparent to semi-transparent and in color vary from rose-red to deep crimson. Cleavage parallel to the base is indistinct, and the crystals appear to be traversed by irregular cracks in all directions. The cleavage parallel to $\frac{1}{4}R$ and R, as noted in the Greenland eudialyte, has disappeared almost entirely from these crystals. The surface of the crystal is in some cases covered by a yellowish coating of altered material; this, however, does not appear to diminish its brilliancy, but when it occurs on the base increases the luster to mother of pearl.

The crystals may be divided according to their form into two classes: first, those in which the negative rhombohedrons predominate, and second, those in which the positive ones are the larger. In general, the crystals are terminated above and below by hexagonal basal planes, but these occasionally become triangular or disappear entirely. The most satisfactory crystal for the measurement of angles was one of only about 3^{mm} in its greatest diameter and of half that thickness. This crystal belongs to that group in which the negative rhombohedrons predominate, and is shown in fig. 1. The measurements from this, combined with those from several other crystals, are given below, and after each measured angle the extreme variation from the mean is appended.

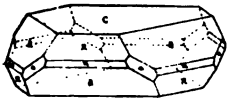

Fig. 1

The axial ratio, as calculated from measurements, made on three very good crystals, of the angle between the base and the largest rhombohedron, $-\frac{1}{2}R$, is found to be $a:c = 1:2{\cdot}1174$. As this is deduced from a mean of not less than ten angles, none of which varied more than 25 seconds from the mean angle, 50° 43′ 6″, it is evident that it cannot be far out of the way for the Arkansas variety of eudialyte. Brögger in his splendid work, "Die Mineralien der Syenitpegmatitgänge der Südnorwegischen Augite- und Nephelin-syenite,"[*] considers the latest measurements of von Kokscharow[†] the most correct for eudialyte. Von Kokscharow gives $a:c = 1:2{\cdot}1129$, which differs but little from the

[*] W. C. Brögger. Zeitschrift für Kryst. und Mineral, xvi, p. 498, 1890.

[†] Von Kokscharow, Verhandl. der kais. russ. min. Gesellschaft zu St. Petersburg, II, xiv, 205, 1879.

dinarily accepted figures, $a:c = 1:2{\cdot}1117$, while the value the Arkansas variety is considerably larger.

The following faces have been observed and measured:

$$c = 0R\,(0001),\ a = \infty P2\,(11\bar{2}0),\ R = +R\,(10\bar{1}1),$$
$$d = -\tfrac{1}{2}R\,(01\bar{1}2),\ n = -2R\,(02\bar{2}1).$$

Faces.	Mean angle.	Calculated.	Variation.	Von Koksch. Calculated.
d, $(0001):(01\bar{1}2)$	50° 43′ 6″	50° 43′ 6″	0′ 24″	50° 38′
R, $(0001):(10\bar{1}1)$	67 53 48	67 45 24	3 12	67 42
n, $(0001):(02\bar{2}1)$	78 25	78 26 35	10 30	78 25
a, $(0001):(11\bar{2}0)$	89 56*	90 0	0 15	90 0
a, $(10\bar{1}\bar{2}):(11\bar{2}0)$	47 49 30	47 54 29	4 30	47 58
d, $(10\bar{1}\bar{2}):(01\bar{1}2)$	84 21	84 11 2	1 reading	84 4

The variation of these angles and of the axial ratio from ose of von Kokscharow would suggest some corresponding riation in the chemical composition, and it is probable that analysis on which Mr. Hidden is engaged will bring out is difference.

An excellent example of that class of crystals in which the sitive rhombohedrons predominate is found in a small specien—not more than 4^{mm} in its greatest diameter—loaned me Mr. C. S. Bement. This is shown in fig. 2. In this crystal e face, $+R$ $(10\bar{1}1)$, is so over-develed that all the rest of the faces seem arfed by it. At the first glance, and fact until the crystal is carefully meased, this large face would be mistaken r the base, and the fact that opposite it, the crystal is terminated by a sixled pyramid would seem to support this view.

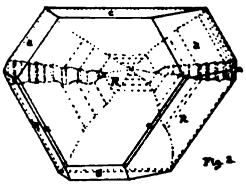

Fig. 2.

The crystal is, in reality, to be placed as shown in the cut, d the faces, which make up the front of the crystal, are desated by the same letters as in the preceding figure. The es forming the back are for the most part composed of own forms in oscillatory combination. Besides these well own faces a large number of new ones appear, of which, wever, only a few are large and sharp enough to be worthy special mention. The most important of these forms are as lows:

$$-\tfrac{3}{11}R\,(0\,.\,3\,.\,\bar{3}\,.\,11).\ \tfrac{1}{4}R\,(10\bar{1}4),\ \tfrac{1}{5}R\,(10\bar{1}5)\ \text{and}\ -\tfrac{1}{4}R5\,(23\bar{6}3).$$

The angles, measured as nearly as possible, were as follows:

Angle.	Measured.	Calculated.
$0R: -\tfrac{3}{11}R,\ (0001):(0\cdot 3\cdot \bar{3}\cdot 11)$	33° 54′	33° 41′ 52″
$0R: \tfrac{1}{4}R,\ (0001):(10\bar{1}4)$	31 54 (±30′)	31 26 12
$0R: \tfrac{1}{5}R,\ (0001):(10\bar{1}5)$	25 59 33″	26 3 35

The faces at the back of the crystal lying in the vertical ne and beginning at the top are: $0R$, 0001; $-\tfrac{3}{11}R$, $\bar{3}\cdot 0\cdot 3\cdot 11$;

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[1] Brögger, l. c., measured this angle on Norwegian eucolite as 89° 58′ 30″.

$-\frac{1}{2}R$, $\bar{1}012$ (large); $-\frac{1}{m}R$, $\bar{1}01m$; (point at back) $\frac{1}{n}R$, $\bar{1}01\bar{n}$; $\frac{1}{4}R$, $\bar{1}01\bar{4}$ (large but dull); $\frac{1}{5}R$, $\bar{1}01\bar{5}$ and $0R$, $000\bar{1}$ (bottom).

The right and left inclined zones at the back are made up of the following faces; R, $0\bar{1}11$ and $\bar{1}101$; the prisms $\infty P2$, $\bar{1}\bar{1}20$ and $\bar{2}110$; (point at back) $-\frac{1}{2}R$, $\bar{1}10\bar{2}$ and $0\bar{1}1\bar{2}$. The small zones lying back of *a* ($\infty P2$, $\bar{1}2\bar{1}0$ and $1\bar{2}10$) are made up of a recurrence of the prisms with the scalenohedrons $-\frac{2}{3}R5$, $\bar{2}36\bar{3}$ and $\bar{6}32\bar{3}$ (determinable only through zone relations.)

In order to make sure that the crystal was properly placed and the faces correctly determined, it was imbedded in a short piece of glass tubing just large enough to hold it, and which was filled with Canada balsam. This was then placed on an object glass and a thin glass cover placed over it.* The outside of the glass tube was covered with black paint, in order to cut off any side reflections, and the preparation was then examined under the polariscope. Owing to the thickness and irregularity of the crystal, the black cross was not very plain, but it was evident on revolving the stage of the polariscope that there was no extinction such as was observed when the crystal was placed in any other position.

The specific gravity is comparatively low and lies between 2·804 and 2·833 at 15° C. These values were obtained from those crystals which were measured, and the lowest was that of the crystal figured in No. 2. The determination was made by means of a cadmium-borotungstate solution, in which the crystals were placed and which was then brought to such a density that the mineral remained suspended, neither rising nor sinking. The specific gravity of the solution was then determined by means of a 12 cc. pycnometer.

Thin sections, cut at right angles to the vertical axis, show in parallel light a pink color, and between crossed nicols remain perfectly dark during a complete revolution of the stage. In convergent polarized light such sections show a wide black cross which sometimes opens a little owing to slight optical anomalies, but no colored rings appear. Both the double refraction and the index of refraction are weak. The index is lower than that of Canada balsam and the surface of the section appears smooth. The character of the double refraction is *positive.* By sinking the polarizer and the converging lens, the irregular cleavage, which lies approximately parallel to $\frac{1}{4}R$ $(10\bar{1}4)$, becomes visible.

The mineral is comparatively free from inclusions for a crystal which was formed as late in the period of solidification of the rock as this. Magnetite and ægyrite or acmite are the ıly inclusions which have been observed. It appears as if metimes eudialyte and sometimes orthoclase was formed ·st, for first one and then the other is found in idiomorphic ystals. On the whole the eudialyte appears to be the earlier the two. Decomposition takes place very rapidly.

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* Since making this experiment I have received Professor C. Klein's exhaustive paper on this method of examining crystals without cutting them. Sitzungsber. d. [illegible] Berlin, xviii, p. 347, 1890.

Eucolite.—According to Brögger,* all those crystals which .ve the form of eudialyte, and essentially its chemical compo- ;ion, but *negative* double refraction in place of *positive*, are be considered *eucolite.* It appears therefore that the yellow- ı brown crystals, bearing a great resemblance in form and ;e to eudialyte, but which are characterized by their *negative* ›uble refraction, are to be classed under this head. The ystals which appear in the Arkansas rock are of a much ;hter brown or brownish yellow color than those from orway. The cleavage parallel to the base (0001) is much ore pronounced than in eudialyte, but that in other directions about equally poor with that already noted.

The following faces have been observed (fig. 3): $c = 0R$ 001), $R = +R$ $(10\bar{1}1)$, $d = -\frac{1}{2}R$ $(01\bar{1}2)$, $g = \infty P$ $(10\bar{1}0)$, $a =$ $P2$ $(11\bar{2}0)$. Some of the angles between these faces and the se have been measured, but the poor flections prevent the obtaining of accu- te results. The angles recorded are ·obably not nearer than from 15′ to 30′ the true angles. Owing to these large nits of error, it is impossible to calcu- te any axial ratio for this mineral, but e angles as measured do not differ very much from the cor- sponding angles on eudialyte.

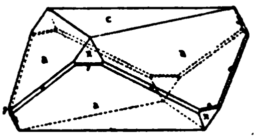

Fig 3

Angle.	Measured.	Calculated.
$c: d$ (0001):(01$\bar{1}$2)	50° 40′ 30″	50° 43′ 6″
$c: R$ (0001):(10$\bar{1}$1)	67 12	67 45 24
$c: a$ (0001):(11$\bar{2}$0)	89 53	90
$c: g$ (0001):(10$\bar{1}$0)	90 25	90

The specific gravity taken in the same way as that of eudia- te gave 2·6244 to 2·6630 at 15° C. This is extremely low, ıt even after bringing in a correction for adhering orthoclase ɔ. gr. = 2·55–2·62) the figures would not be much higher. ardness 5 to 5·5.

In thin sections this mineral appears semi-transparent, and is a white to a very light yellow color. In convergent polar- ɜd light, a section perpendicular to the principal axis shows black cross which when tested with a mica plate establishes e negative character of the double refraction very plainly. ıe double refraction appears weaker than in eudialyte. Mag- ıtite and ægyrite appear to be the only inclusions. Some crystals were found which were made up of both pink and yellowish brown material, and in these cases it was always found that the former was positive and the latter negative.

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* L. c. page 489.

Wilhelm Ramsay[*] in his "Geologische Beobachtungen auf den Halbinsel Kola" has observed that, in the eudialyte of the nepheline syenite, which he describes, both positive and negative as well as isotropic zones appear, but that no difference in color nor in the indices of refraction between the various parts was detéctable. Ramsay's observations were made by means of a selenite plate on sections, which were slightly inclined to the principal axis, while those on the Arkansas mineral were made by means of a quarter-undulation mica plate on sections parallel to the base.

From the low specific gravity and hardness, as well as the want of complete transparency in the eucolite crystals, it may well be suspected that these crystals are decomposed or weathered eudialyte. To these facts may be added the observations that, in cases where eudialyte has begun to weather, it is found in the form of pink grains surrounded by a soft yellowish brown powder, which resembles very closely the eucolite just described. Moreover it is probable that the yellowish coatings observed on the surface of the eudialyte crystals already described are made up of this same brownish yellow mineral. A determination of the amount of water in a specimen of the eucolite would be of use in deciding the question of its origin.

Both eudialyte and eucolite occur in two places in Magnet Cove; one, one hundred meters northeast of the point where the Hot Springs turnpike crosses Cove Creek, and the other on "the branch" about 150 meters east of where it empties into Cove Creek. Indications of eudialyte have been observed in the elæolite syenite of Saline County, Ark., on the property of Sol. Nethercutt, about seven miles (11 km.) N.E. of Benton. (N.W. of S.E. of Sec. 16, 2S. 14 W.) At this point the mineral was so badly weathered that an exact determination was impossible.

Besides the ægyrite, elæolite and orthoclase of the rock in which the eudialyte occurs, there are found as accessory minerals beautiful little idiomorphic titanites and apatites. As decomposition products there appear ozarkite (thomsonite) and manganopectolite,[†] which may be due in part at least to the weathering of eudialyte as well as of the other constituents of the rock.

Petrographical Laboratory, Clark University,
Worcester, Mass., June, 1890.

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[*] Wilhelm Ramsay. Fennia, Bulletin de la Société de géographie de Finland, iii, No. 7, pages 42 and 43.

[†] J. F. Williams. Manganopektolit. Ein Neues Mineral aus Magnet Cove, Ark. Zeitsch. Kryst. Min., xviii, 1890.

ART. LIX.—*Prediction of Cold-waves from Signal Service Weather Maps;* by T. RUSSELL.

[Read before the American Association for the Advancement of Science, at Indianapolis, August 25, 1890, by T. Russell, Assistant Professor, Signal Service.]

IN addition to the regular fall of temperature that takes place from day to night, there are irregular falls occurring from time to time. The extent of country covered by these falls is various at different times. When the fall of temperature in twenty-four hours is twenty degrees or more and covers an area of at least fifty thousand square miles and the temperature in any part of the area goes as low as 36° it is called a cold-wave. Answering to this definition, there have been in the United States in the past ten years, 1880 to 1890, six hundred and wenty-one cold-waves, as shown by the 7 A. M. weather-maps of the Signal Service.

In Table I, is given the number of cold-waves, of various exents, according to the area enclosed by the twenty-degree emperature-fall line, that have occurred in ten years, in the months of October, November, December, January, February and March.

TABLE I.

er of cold-waves, 1880 *to* 1890, *according to extent of twenty-degree temperature-fall areas.*

	50,000 to 100,000.	100,000 to 200,000.	200,000 to 300,000.	300,000 to 400,000.	400,000 to 500,000.	500,000 to 600,000.	600,000 to 700,000.	700,000 to 800,000.	800,000 to 900,000.	900,000 to 1,000,000.	1,000,000 to 1,100,000.	1,100,000 to 1,200,000.
	13	27	25	29	16	13	9	4	3	1	1	2
	23	26	19	24	13	10	6	5	2	2	2	1
	30	24	13	11	12	1	2	1	1	..	..	..
	21	13	2	1	1	..	..	..	..	..	..	..
r	32	14	12	10	8	5	1	..	1	2	..	..
	31	30	21	16	14	5	1	3	5	1	..	..
	150	134	92	91	64	34	19	13	12	6	3	3

The greatest cold-wave was that of January 17, 1882. The twenty-degree fall line included an area of 1,101,000 square miles, and the ten-degree fall line an area of 2,929,000 square miles. There have been in ten years six cold-waves with the area of the twenty-degree fall greater than one million square miles. The magnitude of maximum temperature-fall in cold-waves varies greatly at different times. The different curves of temperature-fall lie one within the other, the twenty-degree within the ten-degree, the thirty within the twenty and so on. There is a gradual increase of temperature-fall from the border of a cold-wave area to the center which is the place of maximum-fall. There have been two cases in ten years where the maximum fall was over sixty degrees, the greatest being sixty-three. There were sixteen cases where the maximum fall was between fifty and sixty degrees; seventy-seven cases with the maximum fall between forty and fifty degrees; two hundred and sixty-two cases between thirty and forty degrees; and two hundred and sixty-four between twenty and thirty.

The Signal Service weather-maps show that these cold-waves always occur over the country covered on the preceding day by an area of low barometric pressure, or over the country covered by an area of high pressure. Where both occur, the cold-waves attain their greatest extent. The cold-waves occur from the center of the areas of low pressure towards the west. There are a few cases where low pressure areas have not been followed by a fall in temperature at their centers. There are twelve of these in ten years where there have been rises in temperature instead of falls around the centers of low pressure. On the other hand, no cold-waves ever occur without the presence of an area of high or low pressure. Why there are exceptions is not known.

The Signal Service observations made at 8 A. M. (at 7 A. M., previous to July 1, 1888) are given on the weather-maps issued daily. The barometric pressure at the various stations reduced to sea-level are generalized by the isobars. The temperatures are shown by the isotherms drawn through places having the same temperature.

A typical case of weather-map preceding a cold-wave is that of February 9, 1885. The map shows a characteristic feature of the isotherms preceding a cold-wave. They run from southwest to northeast in the country covered by the low pressure, and after passing the center bend towards the southeast and east. To the west of the region of high pressure the isotherms bend to the northwest. The general appearance of the isotherms would seem to indicate that the air in the low pressure has progressed from the south, and that in the high from the north, carrying with it the isothermal lines peculiar to those regions. The temperature-falls on February 10, 1885, shown on a map by lines joining the points of equal fall, give areas which are quite regular, having usually the appearance of ellipses one within the other. The total temperature-fall on a map has graphically the semblance of a cone. The temperature-fall lines are sections of planes with the cone. The maximum or greatest fall of temperature in the center is the altitude of the cone, and the area enclosed by the lines of no change is its base.

An examination of the maps preceding cold-waves shows that the extent of cold-wave is dependent on the extent of the area of low pressure and the area of high pressure on the day preceding it. The extent of cold-wave depends very greatly on the density or sparseness of the isothermal lines in the region of the low area and to the west of it. When they are numerous and close together, the falls will be very great and will cover a wide extent of country. The maps preceding cold-waves vary very much as regards isotherms. There is always some diminution of temperature to the northwest of a low area. Sometimes it is not more than twenty degrees in a distance of 500 miles from the center, and sometimes eighty degrees in the same distance.

To show to what extent the amount of temperature-fall and the area of fall depend on the variation of barometric pressure and contrast of temperature, the means in a number of selected cases are shown in Table II.

TABLE II.

Summary of Pressure and Temperature Gradients, and Mean Temperature Falls.

Mean Temperature Falls.		Mean Temp. Grad'nt per 500 miles.	Mean Pres. Grad'nt per 500 miles. Inches.	Mean extent of cold-wave.
53°·6	16 cases	55°	0·66	26·1
43°·3	60 cases	47°	0·56	15·1
33°·5	"	44°	0·59	10·0
24°·0	"	34°	0·46	3·7
14°·3	"	23°	0·40	

In forming the means in Table II, sixty cases each of falls between thirty and forty, twenty and thirty, and ten to twenty were selected, one from each month, October to March, during the ten years. The changes less than twenty degrees do not class as cold-waves, but are given, to show the dependence in magnitude of the temperature-fall on the pressure and temperature gradients in the case of small changes. The last column of Table II, contains the extent of cold-wave, the unit being a fall of twenty degrees over an area of 50,000 square miles, or ten degrees over an area of 100,000. The extent of fall in cold-waves, including all the fall greater than ten degrees, but not including any less than ten degrees, varies in different cases from 5 to 60 on this basis. The temperature-fall is computed as the contents of a rough cone. The areas of the falls are measured with a planimeter and the altitude expressed in units of ten degrees of the greatest fall in temperature.

The shapes and relative positions of high and low areas of pressure preceding cold-waves are very various. The principal types most frequently recurring are as follows:

1. A low pressure without any accompanying high pressure. Cold-waves with this type are not apt to be important or extensive, unless the area is continental in extent. With a central pressure as low as 29·3 inches, and a distance across the thirty-inch isobar of 1,600 miles, the cold-wave is apt to be considerable.

2. A low pressure area with a high to the northwest of i
This is the most frequently occurring type. The cold-wav

accompanying it may be of any extent from the smallest to the largest.

3. A great area of high pressure, with a slight or very ill-defined low pressure, irregular in shape to the southeast of it, or very far to the east. The cold-waves are not apt to be great in this case. The area of temperature-fall is a long narrow strip extending from southwest to northeast, and never reaching more than 300 miles from the southeastern edge of the high area.

4. An area of low pressure with an area of high southwest of it. The temperature-fall area is a long narrow strip in this case. This type is usually a sequence of type 2 and always follows after a severe cold-wave has prevailed the day before in country farther to the west and north.

5. A double V-shaped area of low pressure, one in the region of the Great Lakes open to the northeast, the other in Louisiana or Texas and open to the southwest, a great area of high pressure in between the two, to the northwest. The cold-waves of greatest extent have occurred with this type.

6. A double low, one in the Lake Region and the other on the Atlantic coast. The cold-waves with this type are always extensive, but keep well towards the north.

These varieties may be still further subdivided according to the shape and position of the isobars in the area of low pressure. The low may have closed isobars, or it may be open in any direction. The closed isobars may be circular or elliptical. When elliptical, the long axis may be from northeast to southwest, from north to south, east to west, or northwest to southeast. The latter variety is very unusual. The cold-waves following each of these varieties have distinctive features. These various types have distinctive features in the areas of twenty-degree fall following them. The longer axis of the area of temperature fall extends in the direction in which the isobars are open, etc.

The method given here for the prediction of cold-waves, does not give a correct result at all times. It represents very fairly the average of cases that occur; though in a few cases, it gives largely erroneous results. It is purely empirical. What follows certain combinations of isobars and isotherms is seen from past weather-maps, and it becomes a question how to formulate the conditions and use them, for judging what may occur in any special case in the future.

From an examination of the charts of temperature-fall in connection with the weather-map twenty-four hours preceding, it will appear that the extent of the cold wave depends on the extent and depth of the area of low pressure. It likewise depends on the extent and height of the area of high pressure.

When both a low and high pressure occur together, the cold wave is apt to be very great. The surest indication of a coming great fall of temperature, both deep and extensive, is a crowded condition of the isothermal lines to the northwest of n area of low pressure. This condition is usually the result of a great fall of temperature in the preceding twenty-four hours, in a district to the west and north. Sometimes, however, this crowded condition of the isotherms is the result of a low cooling over a wide area of country, lasting several days. Then a low area of pressure putting in an appearance to the outheast of it, the next day there follows a great and extenive fall of temperature, without any very great fall the day preceding. At times, there is a regular progression of the reas of fall from west to east, or southeast. Areas of low pressure appearing in the vicinity of Lake Superior, with a high area to the west, have temperature-falls on the next day t places east of the Missouri River and skirting along as far outh as the Ohio River.

One of the most important types of map is that of a low area of pressure in Texas and a great high to the north. Areas of great temperature-fall always follow this type, with the long axis extending north to south. The greatest falls occur in the outhwest. The areas of fall on the next day are farther to he east, and later, falls follow to the north, in Maryland, Pennsylvania, New Jersey and New York. This is a type for which it is possible, when the high and low areas are large, to make successful predictions of cold-waves for the eastern States wo days in advance.

Inasmuch as the extent and depth of temperature-fall depend on the extent of the areas of high and low pressure, it was decided to ascertain how far this was true, and to determine if possible the numerical relation between them. The areas enclosed by the temperature-fall lines of ten, twenty, thirty, orty degrees, etc., in the various cold-waves were measured by means of a planimeter on maps of the United States on a scale of $\frac{1}{10,000,000}$. The areas between the isobars of high and ow areas of pressure on the maps preceding cold-waves were measured in the same way. The areas between the isothermal ines in the region covered by the areas of high and low pressure were also measured.

The method proposed for the prediction of cold-wave, is as ollows:

1. From the measured extent of the high and low area of pressure always preceding cold-waves to determine what the otal extent of the fall in the cold-wave will be.
2. To determine the maximum fall of temperature that s to take place in a cold-wave.

3. The extent of cold-wave being known, which is the contents of a cone, and the altitude being known, which is the maximum fall of temperature expressed in units of ten degrees, then from suitably prepared tables, the areas included by the ten and twenty degree temperature-fall lines to be taken, these lines being the sections of planes with the cone.

4. The various shapes that the twenty degree temperature-fall areas take with different types of high and low pressure will be determined. The shape of the areas will be taken as exactly elliptical, with varying ratio of axes in different cases. This is not strictly the shape of temperature-fall areas in actual cold-waves, but it is sufficiently near for practical purposes, and the best that can be adopted. In more than 90 per cent of the cases, a regular ellipse will represent actual temperature-falls with errors not greater than six degrees.

5. The location of point of greatest temperature-fall will be determined, and the position of the longer axis of the twenty-degree fall area.

6. A previously prepared piece of card-board of the size and shape of the twenty-degree fall area will be placed on a map in its proper position and a line drawn around it. The thirty degree, forty degree, etc., temperature-fall lines will be drawn in with regard to this twenty degree fall line, and the point of maximum fall.

7. From these curves the falls at various stations in the region covered can be estimated, and the isothermal lines drawn for the day on which the cold-wave is to prevail. The isothermal lines in a region where a cold-wave prevails, always have a certain smoothness and definiteness of sweep. If the predicted isothermal lines are crooked and irregular, some slight adjustment can be made, and new isotherms put in, so as to represent the average position of the ones first drawn.

Extent of Cold-Wave.

The extent of a cold-wave has been taken, as proportional to the extent of the area of low pressure multiplied by an unknown factor, plus the extent of the high area multiplied by another unknown factor, plus another term, composed of the product of an unknown factor by the extent of low area of pressure, and a number expressing the density of the isothermal lines throughout the region of the high and low areas. The unit of deficiency of pressure in the low area, below a pressure of 30 inches and excess in the high, is taken as one inch over an area of 100,000 square miles. In different cases the number expressing this excess or deficiency of pressure varies from a small fraction of a unit to as much as ten units. Observation equations were formed on this plan, of the form,

$Hh+Ll+Ll_{,}F-E=0$. h, l and $l_{,}$, are the unknown quantities and, E, the extent of cold-wave; H and L, are the measured extents of high and low pressure. As regards F, the number expressive of the density of the isothermal lines, it was derived in the following way.

Consider two contiguous areas, between three successive isotherms. The tendency is for the wind to blow from the high area towards the low, and carry the air from places of low temperature to those where it is high. The mean temperature of a strip between two isotherms as compared with a strip adjoining it is ten degrees different, the one to the west and north being the lower. If the area of higher temperature is of less extent than the lower one, there is a possibility of all the air from the lower one overflowing the higher, and that the fall in temperature will be equal in extent to the area of the higher multiplied by one, their difference of temperature being ten degrees. If the area of lower temperature is less than the higher one, it is not likely that it will change the temperature any more than the area of the lower multiplied by the difference of temperature unless there is cold air coming from above. Consider a third area with respect to the one of highest temperature. The fall of temperature produced by it may be taken in extent, as equal to the area of the smaller one of the two areas multiplied by two, the difference of their mean temperatures being twenty degrees, but somewhat less than this on account of the two areas being farther apart than in the case of the first two considered. Part of the low temperature is expended in lowering the temperature of the intervening area. It is not known what the law is, according to which this effect diminishes with distance of the areas apart. There is some reason, however, for believing that it is inversely as their distance apart. The effects of the areas, in causing extent of fall, have been taken as inversely proportional to their distances apart expressed in units of one hundred miles. Considering all the other areas with respect to the area of highest temperature, in a similar manner a series of numbers will be obtained, expressive of the possible extent of temperature-fall. The next area of temperature below the one of highest temperature, will in like manner give a similar series of numbers, and likewise a third area considered with respect to all those below it will give a series, and so on, until the last two areas are taken into account which give a single number. The sum of all these numbers gives a total number expressive of the possibility of temperature-fall, provided there is sufficient of a low area to induce such a circulation of the air, that the air from places of low temperature will reach places where it is high. The more extensive and deep the area of low pressure, the more this will be accomplished. Accordingly, a term is included in the equation which gives the temperature-fall, which is proportional to this number multiplied by the extent of the low area and an unknown quantity. This number expressive of density or sparseness of isotherms in the case of different weather-maps preceding cold-waves varies from 5 to 95.

To establish the numerical relation between the extent of cold-wave and the extent of high and low areas of pressure, 127 cases of cold-wave were selected from those that have occurred in ten years. They were so chosen as to include the greatest possible variety in extent of cold-wave from the smallest to the largest, the greatest and least areas of high and low pressure concerned in their production, cases in which the "high" was in different positions with respect to the "low," and cases of the greatest diversity of the isothermal lines passing through the low area.

Normal equations were formed, and from them the values of the unknown quantities derived:

$$h = 2{\cdot}75,\ l = 3{\cdot}15,\ l_{,} = 0{\cdot}0547$$

From the residuals obtained by substituting the values of the unknown quantities in the observation-equations, the probable error in the extent of a cold-wave derived by this method was found to be ± 5. The average extent of cold-wave in the 127 cases was 20. The extent of different cold-waves varied from 5 to 60.

Several different forms of equation were tried. The one described, gave more satisfactory values of the residuals than any of the others. From a consideration of the residuals in the various methods tried, it was inferred that the fall of temperature in a cold-wave must be composed of two parts. One part depends on the presence of a high or low area of pressure, and the other on the transmission of air from places in the northwest, where it is cold, to places where the temperature is high, in the vicinity of the low area. The first part probably results from the intermixture of air near the ground with that from a great altitude, this intermixture resulting from a great diminution of temperature upward in the air. In Winter, on account of the greater lengths of the nights, there is excessive cooling of the upper layers of air. The determining factor of a convective interchange, is the upward diminution of temperature. The air over a wide area of country being in unstable equilibrium, a circumstance, such as a slight excess of heating at the ground may be the cause of an intermixture of the strata throughout a great height. Intermixture would cause the air to become nearly uniform in temperature, which would cause a fall

; the surface of the earth, and a rise in temperature high up in ie air. This latter, however, would not be maintained long on ccount of the greater radiation in the upper air, which would iuse the temperature to diminish rapidly to the normal pecu- ır to the altitude and the time of the year. A mixture of the r throughout a height of five miles, computation shows, would iuse a fall in temperature of forty degrees, if the temperature the surface of the earth is 60°.

The change of temperature upward in the air is very slight a region covered by an area of high pressure. This is the gion where a cold-wave is prevailing and intermixture has ken place. In fact, there is sometimes in such a region an crease of temperature upward, which is, however, mostly due local causes, a ridge or peak radiating strongly into space ıring the night, and the thin layer of air cooled by contact ith it, flowing down over the lower portions of the land into ılleys, and giving rise to an abnormal contrast of temperature slightly differing altitudes.

The fact that most of the severe cold-waves in the northwest art in the afternoon, just after the occurrence of the maxi- um temperature, tends to strengthen this view. The higher p in the air, the less the diurnal range of temperature. At ie time of maximum temperature at the surface of the earth ie rate of upward diminution of temperature must be greatest, ıd consequently at that time the greatest tendency to an in- rchange of the air above and below. The fact that the same ensity of isotherms with same extent of high and low in dif- rent cold-waves, do not always produce the same extent of mperature-fall proves conclusively that the fall is not due en- rely to progress of cold air from the northwest, or dependent lely on temperature conditions at the surface of the ground, ıt that part of it must come from above.

Cases can be shown on the Signal Service weather-maps, here the fall of temperature certainly cannot be due to pro- ess of air from places of low temperature to those of high ıless it comes down from the upper air, because there is no wer temperature to the northwest to be carried by the winds.

In the high area, the main part of the cold-wave is due to the nvective action in high and low strata. The high is to some tent merely the result of low temperature. The equation ill not admit of a term consisting of the extent of high area ultiplied by the factor dependent on the density of the iso- ıerms. There are a few cases, however, where a slight term this kind would improve the residuals. An area of high ırometer no greater than 30·4 inches has very little power to ansmit or produce a cold-wave to the east or southeast of it. p to that limit, the high pressure is mainly the result of the low temperature over the area, and there is no appreciable cold-wave without a very considerable low to the east. In the low area, the fall of temperature is due both to the intermixture of upper and lower air and the presence of cold air brought from the northwest by the action of the typical winds around it.

The greatest fall of temperature.

An examination of the weather-maps in 217 cases preceding cold-waves shows, that the greatest falls in 134 cases occurred inside of the lowest isobar of the low area of pressure or within 100 miles of the center of the low. In 62 cases, it was south of the center of the low 200 miles or more. In 8 cases it was north of the center; in 4, west of it; in 3, east of it; and in 6 cases so remote from the center as to have no apparent relation to it. In at least 80 per cent of all the cases of cold-waves, the place of greatest temperature-fall can be located twenty-four hours beforehand somewhere on the map within a radius of one hundred miles of its true place by taking it at the place of highest temperature within 100 miles of the center of the low.

The magnitude of greatest temperature-fall is conspicuously dependent upon the temperature gradient on the weather-map preceding it. The values of maximum temperature-fall, pressure and temperature gradients given in Table II. might be used for deriving the greatest fall. Taking the fall as proportional to the product of the temperature gradient by the pressure gradients in five hundred miles, the mean greatest falls of 53·6, 43·3, 33·5, 24·0 and 14·3 degrees, give values for the factor respectively of 1·49, 1·66, 1·29, 1·54, 1·55, the mean of which is 1·48. This factor multiplied by the product of the 500 mile pressure and temperature gradient in any case, will give an approximate value of the maximum fall in a coming cold-wave. The value found in this way would be good if the areas between the isotherms were more regular than is usually the case.

A better method was found to be the following:

On a line drawn from the point of greatest prospective temperature-fall, and perpendicular to the isotherms, about where they are closest together on the map, measure the distances between the isotherms. The temperature at the place of greatest fall after the cold-wave has prevailed, will be the weighted mean of the mean temperatures of the various sections of the line between the isotherms, the weights being taken directly as the lengths of the various sections, and inversely as the distances of their centers from the point of greatest prospective fall. The mean of the temperature from the point of greatest fall to the first isotherm to the northwest of it, or for at least a distance of 200 miles from the point of greatest fall when there is more than one isotherm in the distance, is taken with a weight of one. The mean temperature of a section is the mean of its bounding isotherms. When the decrease of temperature towards the northwest in a distance of 500 miles is not more than thirty degrees, the greatest fall may be taken as not greater than five-sixths of the change in 500 miles.

The probable error of greatest temperature-fall by this rule as derived from 201 cases of cold-waves is about ±2·5 degrees for falls of twenty degrees and ±6·5 degrees for falls of fifty degrees. Table III shows the distribution of errors.

TABLE III.

Errors in Computed Temperature Falls.

Cases.	Error in degrees.	Cases.	Error in degrees.
14	0°	5	±10°
36	±1	4	±11
24	±2	3	±12
22	±3	7	±13
14	±4	3	±14
19	±5	1	±15
19	±6	4	±16
10	±7	1	±17
15	±8	2	±18
8	±9		

The computed fall is less than the observed. On the average it is less by one degree for falls of twenty degrees; by two degrees for falls of thirty; by half a degree for falls of forty; and by five degrees for falls of fifty degrees. The average of all cases gives the computed fall two degrees less than the observed.

This method of deriving the maximum fall can only be used where the pressure gradient is at least 0·4 of an inch in 500 miles. It is worthy of note that the mean temperature throughout the areas of high and low pressure, as derived from the planimeter measurements of areas between isotherms, agrees in most cases within a few degrees with the temperature at the place of greatest fall after the fall has occurred as computed by this rule. Where the computed falls differ greatly from the observed, probably correspond to times of widely differing diminution of temperature upward in the air.

With the computed maximum fall derived in this way, and the computed extent of temperature-fall, the areas of ten and twenty-degree temperature-falls can be taken from suitably prepared tables. The agreement of the computed and observed areas is on the whole tolerably satisfactory. It is difficult to estimate the accuracy of the method without a map for each special case. There are two cases where the method fails badly, those of Dec. 5, 1885, and Dec. 20, 1887, when there were twenty-degree fall areas of 863,000 and 723,000 square miles and the method gives no twenty-degree fall. There are twenty-four cases where the observed area being 300,000 square miles or more, the computed is less than half the observed and may be classed as not good. There are four cases of over 300,000 square miles where the computed area is more than twice as great as the observed area. In the other cases the agreement is tolerably good.

Shape and Position of Twenty-Degree Temperature-Fall Area.

In the case of areas of twenty-degree fall greater than 200,000 square miles when the "high" is to the northwest of the low area, the ratio of the axes of the area in the average of cases is 2·5 to 1·0 For the case of the high southwest of the low, the ratio is 4·0 to 1·0. In double V-shaped lows and exceptionally long areas of low pressure, the ratio is about 5·0 to 1·0. Lows accompanied by highs no greater than 30·3 inches in pressure have the fall areas of same general shape as the isobars of the low area.

Where the isothermal lines are close together, which is always the case in a great cold-wave, the long axis is pretty certain to be at least two and a half times the length of the short one.

The position of the long axis is usually from southwest to northeast. It is parallel to the long axis of the area of low pressure or parallel to the general direction of the isotherms. It is always sure to extend in the direction of the open end of the low area of pressure. The shape of the ten-degree temperature-fall area pretty generally conforms to the shape of the twenty-degree fall area. The ten-degree falls very generally overlap on successive days. The twenty-degree fall areas rarely overlap and when they do, only slightly, not more than throughout a strip fifty miles in width in the case of the very greatest cold-waves. The larger the twenty-degree fall areas are, the more likely they are to be just tangent to each other or slightly overlap. When a well-defined area of twenty-degree fall has already occurred, a consideration of its distance from the center of low pressure, or point of prospective greatest temperature-fall, is of service in determining what the length of one axis of the twenty-degree fall may be the next day.

At the southern limit of a cold-wave, when there is doubt about the position of the lower boundary of a temperature-fall area, the wind direction is useful in locating its position. In the lower Mississippi valley, when the winds having been northwest, and there have been falls of temperature to the north, and the winds turn to the northeast, no farther falls in the vicinity need be anticipated.

Tables and charts have been prepared showing the lowest and highest 7 A. M. temperatures that have occurred in the months of November, December, January, February and March. These are of use in locating the areas of fall and in estimating by differences the low temperatures that may occur to the east, by comparison with what has already occurred where a cold-wave is prevailing.

There is very little time for extensive or elaborate computations in the work of predicting cold-waves. This fact has been borne in mind in devising the method. It will not require more than half an hour to apply it in any particular case. Planimeter measurements of the extent of high and low areas of pressure were resorted to in the special cases used in determining the constants of the formula. But this is not necessary in determining the extent of an area of low pressure in the prediction of cold-waves. The area computed from the measured lengths of the greatest and least axis of the outside isobar of the area will be sufficient. Considering this area as the base of a cone, and the altitude as the difference between the outside isobar and the lowest barometer reading, its contents can be computed with sufficient accuracy for the purpose required.

The predictions of cold-waves according to this method will be better than those of the past in that part of the country south of the States of Missouri and Kansas and south of the Ohio River. Not much improvement can be expected in the far northwest, where there is no opportunity to measure the extent of the "high," where it is apt to be over a country not covered by observation. Neither can the method give much improvement in the New England States, where the "low" is often out over the ocean and the "high" to the north of the Dominion of Canada. The use of the rule for computing maximum fall will, however, make some improvement in the predictions for these regions. Though only adapted for giving the temperature at the place of greatest fall, it can nevertheless be used for other places, and will give a value for the fall that will certainly not be exceeded.

Fuller details for the use of this method in prediction of cold-waves will be found in the annual report of the Chief Signal Officer for the year 1890.

ART. LX.—*On a peculiar method of Sand-transportation by Rivers*; by JAMES C. GRAHAM.

IT is usually stated that the transporting capacity of a stream is dependent upon (1) the volume and velocity of the current, (2) the size, shape and specific gravity of the sediment, and (3) upon the chemical composition of the water. There has recently come under my observation, however, a case which does not come under the usual interpretation of these conditions. It was a case of the transportation of siliceous sand upon the surface of the water, due to capillary floating.

It is well known that a needle can be placed gently upon the water so as to float, the force of capillary attraction producing a surface tension so as to prevent its sinking. This same principle was being used in removing sand from a bar jutting out from an island in the Connecticut River.

The erosion was being carried on from the side of the bar against which the current did not strike. It took place by gentle ripple waves splashing up against the sand bar (which was at an angle of about 150° to the surface of the water) and upon the retiring of each wave a little float of sand would be on the water. At first these were about the size of a silver quarter of a dollar, but by the union of a number, some floats would be formed of about six inches square. These blotches were so numerous as to be very noticeable in rowing up the river and could be traced for half a mile or more below the bank, though this bank from which the sand came was but a few yards long.

If one of the blotches was disturbed by touching or the too violent action of the waves, it would immediately separate, the particles at once falling to the river bottom.

The above facts seem to me interesting for several reasons.

(1.) It shows that coarse sand *can be* floated away by a current of far less velocity than 0·4545 miles per hour.

(2.) It shows a method of removing sand from the lower side of a forming bar which has gotten above high water mark.

(3.) It indicates a possible explanation of the coarser particles of sand occasionally found in otherwise very fine deposits.

ART. LXI.—*Note on the Cretaceous rocks of Northern California*; by J. S. DILLER.

WHILE preparing a geologic map of the northern portion of the Sacramento Valley, two sections about 30 miles apart of the unaltered Cretaceous rocks upon its western border north f the 40th Parallel were measured by Mr. J. Stanley-Brown nd myself. The measurements were made with Green's quare clinometer compass and a hundred-foot wire. Many ossils were collected along the lines of the sections as well as pon both sides. They have been identified by Mr. T. W. tanton, under the supervision of Dr. C. A. White, who indly furnished information concerning the age of the rocks.

Section on Elder Creek, Tehama Co., Cal.

	Thickness in feet.	
Thin sandstone with a large portion of shales which are locally folded	1115	
Massive sandstone with a few thin beds of shale	160	
Shales containing one bed of sandstone 25 feet thick	665	
Massive sandstone	555	
Soft conglomerate containing Chico fossils	20	
Massive sandstone with thin conglomerates	397	
Shales	136	
Massive conglomerate containing some limestone pebbles	271	
Sandstone, some shale and thin beds of conglomerate	320	
Massive conglomerate	43	
Some sandstone and shale, but chiefly conglomerate with Chico fossils	235	
? Apparent thickness of Chico beds,		3897
Shales with thin sandstones	552	
Shales	585	
Sandstone	50	
Shales containing two beds of sandstone, one 8 ft. and the other 12 ft. in thickness	2090	
Shales and thin sandstones	1674	
Sandstones and shales, then shales only	1158	
? Apparant thickness of Horsetown beds,		6109
Shales, twisted and veined, containing *Aucella*	1795	
Shales with calcareous layers, (much covered)	4968	
" " "	5574	
Shales in belt 700 feet wide much folded		
Shales and shaly sandstones with calcareous layers	2002	
Shales and shaly sandstones,—small sandstones increase, contain *Aucella*	3933	
Shales and thin sandstones	1702	
Apparent thickness of unaltered *Aucella* beds,		1,9974
Apparent total thickness of unaltered Cretaceous strata		2,9978

The top of the Chico beds was not exposed. It lies beneath the newer formations which occupy the middle portion of the Sacramento valley. The apparent thickness of the series may have been somewhat increased by faulting.

Section on North Fork of Cottonwood Creek, Shasta Co., Cal.

Shales containing Chico fossils	621	
Shales with this sandstones	180	
Shales	1908	
Conglomerates and sandstones with many Chico fossils	914	
Thickness of Chico beds,		3623
Shales including 10 feet of sandstone contains numerous Horsetown fossils	2870	
Shales with some sandstones contains numerous Horsetown fossils	1787	
Sandstone with coarse conglomerates at base of series	561	
Thickness of Horsetown beds,		5218
Apparent total thickness of unaltered Cretaceous,		8841

The top of the Chico as in the other section was not exposed. The apparent thickness of the series may have been somewhat increased by faulting, a condition suggested by the occurrence of Chico fossils near the western limit of the Cretaceous rocks. Aucella was not found in this section, and the basal member of the series rests directly and unconformably upon the metamorphic rocks.

U. S. Geol. Survey, Washington, D. C.

ART LXII.—*Magnetic and Gravity Observations on the West Coast of Africa and at some islands in the North and South Atlantic;* by E. D. PRESTON.*

THE value of certain magnetic observations depends on the interval of time between the determinations: gravity observations, when their object is a more accurate knowledge of the shape of the earth, depend for their value on the area over which the stations are scattered. Coast, continental and island stations, as well as those on mountains and plains, each have their own particular evidence to furnish. It must be admitted that this evidence is not always unanimous, but the lack of unanimity may result from a real cause, inherent in the nature of matter, or it may be only apparent and come from the difference in instruments and in the interpretation of results. Then again, if it may be assumed that the mean figure of the earth is already known, as closely as the pendulum will give it, research should be carried on by determining local variations of the force of gravity.

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* Read before the American Association for the Advancement of Science, Indianapolis Meeting, August, 1890. Published by permission of the Superintendent of the U. S. Coast and Geodetic Survey.

It is evident that extended voyages offer exceptional facilities for increasing our knowledge in magnetism and gravitation and should be utilized when possible. Such an occasion presented itself in the fall of 1889 when it was proposed to send an expedition to Africa to observe the total eclipse of the sun on December 22. The eclipse party was under the direction of Professor Todd of Amherst College. Through his courtesy, and by authority of Commodore Dewey, Chief of Equipment and Recruiting, U. S. N., the superintendent of the Coast and Geodetic Survey sent one of the assistants to make magnetic and gravity observations. Originally, work of this nature was only proposed for the eclipse station in Angola. It was noticed, however, that on the return trip, several important stations might be visited without much loss of time, and that these stations had already been occupied by earlier pendulum observers. Permission was therefore granted by the Hon. Secretary of the Navy, for the vessel to stop at the Cape of Good Hope, St. Helena and Ascension long enough to enable the Coast and Geodetic Survey representative, to make his determinations. In addition to this, stops were made at Barbados and Bermuda, and through the kindness of Captain Yates, commanding the "Pensacola," full series of observations were obtained. On the outward trip time was more valuable since it was desirable to reach Angola as soon as possible. For this reason only magnetic work was attempted at the coaling places. There appear then as the result of the trip fourteen magnetic and eight gravity stations, distributed as follows: Azores, Cape Verde Islands, Freetown in Sierra Leone, Elmina on the Gold Coast, St. Paul de Loanda, and Cabiri, in Angola, Capetown, St. Helena, Ascension, Barbados, and Bermuda. On both St. Helena and Ascension the force of gravity was measured at the level of the sea and at the highest elevation practicable. On the former island Jamestown was selected for the lower point, and Napoleon's residence at Longwood, for the upper. The pendulum apparatus was set up in the kitchen of what is known as Napoleon's new house, now leased by Mr. Deason. At Ascension the sea station was at Georgetown—the other was on Green Mountain. Foster's observations at the latter place show a defect of gravity of two oscillations per day as compared with the sea-level—that is to say, that having corrected his oscillations on the summit, for elevation, and for the effect of the mountain, on the supposition that it was solid, he found the result to be less than the number of oscillations, actually counted at the sea-level. As some recent observations on island mountains give results at variance with this, it was desirable to repeat the Ascension work with modern instruments. Indeed, it was to connect with Foster, and to verify his result for Ascension, that an extension of our gravity work was proposed. The entire voyage lasted eight months, of which 123 days were spent on shipboard. The area covered by the stations extends from Washington on the north and west, to Capetown on the south and east, making a range of 73° in latitude and 96° in longitude. It so happens that the most northern station is also the most western, and the most southern the most eastern. The elevations range from 7 feet at Bermuda to 2,250 at Ascension. The magnetic observations at Azores, Cape Verde Islands, Freetown and Elmina were shortened by lack of time, one, or at most two days being devoted to each place; but at all other stations the declination, dip, and horizontal force, were determined on each of three consecutive days, besides, at a few stations, making hourly observations on several other days. At Cabiri the needle remained suspended during the total eclipse, but no abnormal change was noticed. For the gravity work, at every station about 30 swings were made with each pendulum—using them in both positions, and continuing the observations through the entire 24 hours. The pendulums used were Nos. 2 and 3, of the Peirce pattern, being of the invariable reversible type. The length of the former between the knives is one meter, that of the latter a yard. Besides having been employed at numerous home stations, No. 3 has now been swung at 13 foreign ones; including several in the Pacific.

Of the 14 magnetic stations all but one have been occupied by earlier observers. Determinations were made in the Azores between 1497 and 1829; in the Cape Verde Islands between 1841 and 1853; in Sierra Leone between 1826 and 1842; at Freetown, by Sabine, in 1822; at Cape Coast Castle, seven miles from Elmina, in 1838 and 1841. St. Paul de Loanda has a magnetic observatory, and issues published reports containing results for declination, dip and intensity. The work at the Cape of Good Hope between 1840 and 1850, is well known, and Sabine's account of five years' observations at St. Helena from 1841 to 1845, is one of our classic magnetic volumes. The station at Sister's Walk in Jamestown, was selected by Sir James Ross in 1840, but as the values at this point are not normal the Coast Survey station was chosen some distance back from the mountain and midway between it and Ladder Hill. Sister's Walk is close against the foot cliffs of Rupert's Hill. The dip was measured at Ascension in 1822, and all hree elements were determined by the Challenger Expedition n 1876. Observations have been made eight times at the Barados between 1726 and 1844 and six times at Bermuda beween 1831 and 1876. The Coast Survey determinations at he latter place were made on Nonsuch Island at the extreme astern end of the group. They are, undoubtedly, the only nagnetic observations ever made at this place, and it is more han probable that the station will never be re-occupied. This s to be regretted; but it was necessary to utilize the ten days pent in quarantine in order to make steamer connection. The vork had to be done here, if it was to be done at all in Bernuda.

The gravity stations in common with other observers were Capetown, St. Helena and Ascension. Foster's celebrated series includes all of these. Sabine determined gravity at Ascension in 1822 and deFreycinet observed at the Cape in his voyage around the world in 1819. Besides the idea of verifying Foster's result, that Ascension Island is too light, it was highly desirable to connect his service with our own, which now includes island as well as continental stations. But it was assumed sufficient to have the series exactly coincident at two points. Lemon Valley was therefore not re-occupied at St. Helena. Moreover, the Ascension stations are practically identical in the two series, and St. Helena was occupied at the sea as well as at the summit, which gives a third connection with Foster, and supplies a check on his Ascension result.

In order that an approximate estimate might be made for the matter lying above the sea-level at St. Helena, many heights were determined barometrically by Professor Abbe of the U. S. Signal Service. By using these, some idea of the attraction of the mountain may be had, and it will then be seen, whether the islands in the Atlantic and Pacific differ essentially as regards internal structure. Rock specimens were brought from both St. Helena and Ascension. Their densities may give an indication of what we should look for in the gravity results, providing that both islands were subject to the same laws of formation.

The "Pensacola" staid at St. Helena but sixteen days. During this time two stations were selected, the pendulums were swung through six consecutive days and nights at each place, magnetic observations were made on six different days and the instrumental outfit transported to and from the mountain top. Equally rapid progress was made at Ascension, where the conditions were similar in many respects. This amount of work could not have been accomplished, however, without the able and generous assistance of the naval cadets attached to the "Pensacola," and of Professor Bigelow of the eclipse party, to all of whom I wish here to express my obligations. I wish also to tender thanks to Captain A. R. Yates, commanding, and to Lieut. Commander Hanford, executive officer of the "Pensacola." The landing and shipping of the instruments was always a matter requiring care, and was often done under difficulty, yet in the numerous transfers nothing was ever broken or lost.

An account of the trip would be incomplete without a due acknowledgment of the services rendered by the government officials at the different stopping places.

At Loanda the governor of the province of Angola gave us free passes for all railroad travel from the coast to Cabiri, where the party went to observe the eclipse on December 22. At the Cape of Good Hope every facility was given. Her Majesty's Astronomer, Dr. Gill, kindly furnished myself and aid with quarters at the observatory, and made a special time determination every night for pendulum work. The railroad authorities gave passes for a trip to the diamond fields at Kimberly, 600 miles in the interior. As a week was necessary for this, the kind offer could only be accepted by those unoccupied with scientific work. At St. Helena Gov. Antrobus offered the use of the public park for the magnetic observations, and the library room of the police court for the gravity work. The unique character of the island government at Ascension placed us under more than ordinary obligations. As there are no civilians at this place we were necessarily the guests of Her Majesty's Government. Capt. R. H. Napier, R. N., placed at our disposition an entire building in Bunghole Square for the observations at the garrison. The pier was built for the transit, tents were erected for magnetic and astronomical work, and guard duty performed by the marines. A ration per day from the island stores was served to each member of the party during the stay. At Barbados and Bermuda we were again on English soil and received the usual generous welcome. At the former place Governor Sendall came to Hastings and made a personal examination of the instruments and methods of observing. At Bermuda General Newdegate kindly gave us the use of the government launch for the transportation of the instruments from Quarantine Island to St. Georges, besides showing other attentions of an unofficial character.

The definite results, from the observations on this voyage, may be expected before the next meeting of the Association. Whether they show the Atlantic islands to be light or heavy as compared with the continental masses, they will at least add considerable new material for the determination of the earth's figure.

The following table contains a list of the stations with their approximate positions, date of occupation, kind of determinations and initials of observers.

Stations.	Approximate Position.			Kind of Determinations.	Epoch.	Observers.
	φ	λ	feet		1889.	
Washington, Coast Survey Office and Smithsonian	+38° 53′	+77° 1′	34	Magnetic and Gravity.	Sept. and Oct.	P. F.
Azores (Fayal)	+38 32	+28 39	30	Magnetic.	Nov.	P.
Cape Verde Islands (Porto Grande)	+16 53	+24 59	15	Magnetic.	Nov.	P.
Sierra Leone (Freetown)	+ 8 30	+13 14	10	Magnetic	Nov.	P.
Gold Coast (Elmina)	+ 5 5	+ 1 20	10	Magnetic.	Nov.	P.
Angola, Loanda	− 8 49	−13 7	150	Magnetic and Gravity.	Dec.	P. M.
Angola, Cabiri	− 8 47	−13 59	200	Magnetic.	Dec.	P.
					1890.	
Capetown Royal Observatory	−33 56	−18 29	37	Magnetic and Gravity.	Jan. and Feb.	P. Pa.
St. Helena, Jamestown	−15 55	+ 5 42	33	Magnetic and Gravity.	Feb.	P. M. Mac B.
St. Helena, Longwood	−15 57	+ 5 40	1750	Magnetic and Gravity.	Mar.	P. M. Mac B.
Ascension, Georgetown	− 7 56	+14 25	15	Magnetic and Gravity.	Mar.	P. M. W. B.
Ascension, Green Mountain	− 7 57	+14 22	2250	Magnetic and Gravity.	April.	P. M. W. B.
Barbados, Bridgetown	+13 7	+59 36	60	Magnetic and Gravity.	May.	P. M. W. Mac.
Bermuda, Nonsuch Island	+32 21	+64 39	35	Magnetic.	May.	P.
Bermuda, St. Georges	+32 23	+64 40	7	Gravity.	June.	P.
Washington, Smithsonian	+38 53	+77 1	34	Gravity.	July.	P. F.

OBSERVERS.

P.—The Author. F.—S. Forney, U. S. Coast and Geodetic Survey. M.—G. R. Marvel, Naval Cadet, U. S. N. Pa.—J B. Patton, Naval Cadet, U. S. N. Mac.—W. D. MacDougal, Naval Cadet, U. S. N. W.—P. Williams, Naval Cadet, U. S. N. B.—Professor F. H. Bigelow.

ART. LXIII.—*On the Fowlerite variety of Rhodonite from Franklin and Stirling, N. J.;* by L. V. PIRSSON.

THE zinc-bearing rhodonite of Franklin and Stirling Hill, N. J., has long been known under the name of Fowlerite. It was, so far as can be learned, first mentioned by Fowler* in 1825, who speaks of a red siliceous oxide of manganese, which had been lately observed by Dr. Thos. Nuttall. It was also described by Thomson† in 1828. Analyses also have been published by Hermann,‡ Rammelsberg§ and Camac.‖

The crystal form and physical properties of this variety of rhodonite have not been thoroughly investigated. It is, however, important to our knowledge of the species that this should be done, in order to determine how far a departure from the normal type, if any, the introduction of the zinc has caused. A new chemical analysis, upon some of the very fine material which within a few years past has been brought to light also seemed desirable. It is with these objects in view that the present investigation has been made.

The mineral occurs imbedded in calcite, in the outer walls of the mines and it is when these are broken into, in the process of working, that the best specimens have been obtained. The crystals occur of all sizes, from four inches long by one in width and thickness, to individuals of microscopic dimensions and also in large masses crystalline in structure and possessing characteristic cleavage but without crystal faces. Upon dissolving away the calcite covering these lumps, with hydrochloric acid, a side will often be found which is completely covered with interlaced masses of small crystals. The larger crystals also occur in these confused masses and during the past few months, there has been a magnificient specimen of this mineral on exhibition, in New York, consisting of a large group of well formed crystals of the largest size.

The color in general is a beautiful rose-pink and in small and perfect crystals the mineral is transparent. The smaller ones are much more homogeneous than the larger individuals, the latter being often pitted with inclusions of calcite and other material. All specimens that have been observed are completely permeated with cleavage cracks, even those of microscopic size. As a result of this the mineral is extremely brittle.

Like most minerals associated with calcite, the luster of the crystal faces is almost entirely wanting. When present it is seen on the basal plane, the prisms and the 2 (221) pyramid;

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* This Journal, I, ix, 245, 1825.

† Ann. Lyc. N. Y., iii, 28, 1828.

‡ Journ. pr. Chem., xlvii, 6.

§ Min. Chem., 459.

‖ This Journal, II, xiv, 418, 1852.

n the other pinacoids and on all other faces it is almost variably lacking, even though in many cases the flat surface f the planes and the sharp edges between them are quite well reserved. In other examples the edges also are wanting, using a rounding off of the crystal, especially in the zones 01 ∧ 100 and 001 ∧ 010. This rounding is also more noticeable the smaller individuals which are much more highly modied than the larger ones.

All this made the crystallographic investigation of the ineral a difficult matter and very accurate measurements an npossibility. In examining a number of crystals, however, me were found which gave reflections of the signal with a ir degree of accuracy and from the best of these were chosen e angles taken as fundamental. Some faces which had lost eir luster gave no reflections whatever, and not even an pproximate schimmer measurement could be made. The lanes being often well preserved however, the expedient of iving them an extremely thin coating of a varnish of mucilage nd water was adopted and by this means using the δ ocular f Websky tolerably accurate measurements could be made pon them, particularly upon the larger crystals.

The following forms have been observed:

a, 100, i-ī	μ, 401, −4-ī	ε*, 441, −4′
b, 010, i-ĭ	ρ*, $\bar{2}01$, 2-ī	k, $\bar{2}21$, 2′
c, 001, O	φ*, $\bar{4}01$, 4-ī	r, $\bar{1}\bar{1}1$, 1
m, 110, I′	q, 221, −2′	n, $\bar{2}\bar{2}1$, 2
M, $1\bar{1}0$, I		

Of these planes ε, ρ and φ are new. Also on some of the maller crystals the following new forms have been identified, vith only a fair degree of accuracy however, from causes nentioned above: $-\frac{4}{5}'$ 445; $-\frac{8}{3}'$ 883; −6′, 661; on the mallest crystals there are traces of macro- and brachy-pyranids, which cannot be identified with even an approach to ccuracy.

The angles taken as fundamental were

001 ∧ 100; 001 ∧ 110; 100 ∧ 110; $1\bar{1}0$ ∧ 001 and 001 ∧ $\bar{2}21$.

And from these we obtain the axial ratios and angles:

$$\breve{a}:\bar{b}:\dot{c}=1·078:1:0·62627;\ \alpha=103°\ 39';\ \beta=108°\ 48'\ 30'';\ \gamma=81°\ 55'$$

The crystal form of the rhodonite from Pajsberg and Långban has been investigated by G. Flink.* He has made some errors in his calculations and correcting these, we have from his measurements the following ratios and angles:

$$\breve{a}:\bar{b}:\dot{c}=1·0728:1:·6217;\ \alpha=103°\ 18'\ 08'',\ \beta=108°\ 44'\ 15'',\ \gamma=81°\ 39'\ 16''$$

which gives as close an agreement with the above as could be expected, considering the degree of accuracy attained in the measurements.

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* Zeitschrift für Kryst. 1886, pp. 506.

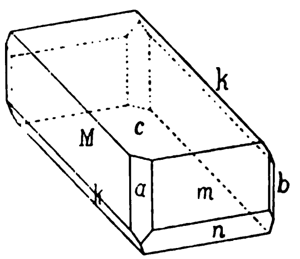
In the following table, for the sake of comparison the calculated angles as presented by Flink are given in the first column, in the second are the angles calculated from the fundamental measurements mentioned above, and lastly those measured on the fowlerite.*

		Calculated.		Measured.			
		Flink.	Author.				
$c \wedge a$,	$001 \wedge 100$	72° 36′ 30″	*72° 30′	72° 30′,	72° 35′,	72° 25′,	
$c \wedge b$,	$001 \wedge 010$	78 42 30	78 16				
$M \wedge m$,	$1\bar{1}0 \wedge 110$	92 28 36	92 49 30″	91 45			
$m \wedge b$,	$110 \wedge 010$	45 52 54	45 32	45 33	45 34		
$M \wedge c$,	$1\bar{1}0 \wedge 001$	86 23 50	*86 41	86 40	†87 15	86 20	86 37
$m \wedge c$,	$110 \wedge 001$	68 44 56	*68 25	68 28	68 24		
$k \wedge c$,	$\bar{2}21 \wedge 001$	62 22 20	*62 21	62 28	63 15		
$M \wedge a$,	$1\bar{1}0 \wedge 100$	43 55 30	44 19 30	43 15			
$m \wedge a$,	$110 \wedge 100$	48 33 6	*48 30				
$r \wedge c$,	$\bar{1}\bar{1}1 \wedge 001$	46 9 27	46 41	46 22	†45 20		
$n \wedge c$,	$\bar{2}\bar{2}1 \wedge 001$	74 23 43	74 42	74 02	74 44	74 48	†75
$q \wedge c$,	$221 \wedge 001$	43 7 23	43 11 30	43 15			
$\epsilon \wedge c$,	$441 \wedge 001$	--------	53 52	53 41			
$\mu \wedge c$,	$401 \wedge 001$	--------	52 21 20	52 25	52 55	†51 40	53 19
$\rho \wedge c$,	$\bar{2}01 \wedge 001$	--------	59 19	58 37			
$\phi \wedge a$,	$\bar{4}01 \wedge 100$	--------	25 25	25 45			
	$001 \wedge 445$	--------	25 47	26 50			
	$001 \wedge 661$	--------	58 15	58 37			
	$001 \wedge 883$	--------	48 05	47 38			

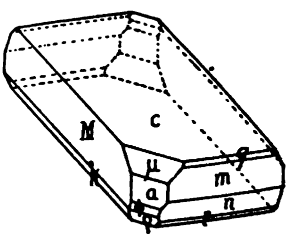
In general, it is to be noted that the more exactly a measurement could be made, it was found to agree with greater closeness with the calculated one for this variety, than with that given by Flink and this is the only hint we have that the introduction of the zinc has produced any change in the axial ratios and angles. In order to determine this, however, much more exact measurements must be made on better material than is at present to be had.

In the figures Nos. 1 and 2 represent the ordinary habit of the larger crystals. Almost invariably they are characterised by a development in the direction of the prism M, $1\bar{1}0$. Fig. 3, however, shows one with a greater development of the prism

1.



2.



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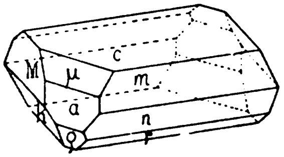
* Those measurements with a dagger (†) in front are the mean of a series of [illegible] with a hand goniometer on lusterless faces of very large crystals.

m, 110. Often instead of having a nearly equal breadth and thickness, there is a greater development of the basal planes, giving rise to flat, tabular forms. One of these is shown in Fig. 4. This particular crystal was also characterized by the pyramid −4′. For reasons already stated, the smallest crystals could not be measured or figured with any exactness, to show their more complex forms. In some the rounding off of the planes is so great that they are nearly spherical in shape.

3.



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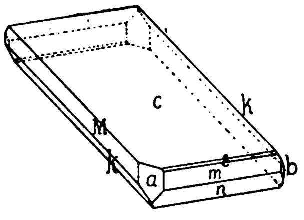

The cleavage is prismatic, perfect, like the normal type of rhodonite; the following were measured $001 \wedge 1\bar{1}0$ (cleavage) 86° 47′, calc. 86° 41′; $1\bar{1}0 \wedge 110$, (cleavage)∧(cleavage) 92° 39½′, calc. 92° 49½′; $001 \wedge 110$ (cleavage), 70°, calc. 68° 25′.

In the endeavor to ascertain whether this variety differed in any degree, in its optical orientation from the normal type, great difficulty was found in making thin sections. It was nearly impossible to grind such a hard brittle material completely filled with cleavage cracks to any satisfactory degree of thinness. After considerable search, however, a small transparent tabular crystal was found which could be used for an oriented basal section and on this the angle of extinction was about 54° from the edge of the prism 110, in the acute angle $110 \wedge 1\bar{1}0$. Flink gives 54° 26′ and from this it is inferred that there is little or no difference in the position of the axes of elasticity.

For the chemical analysis, only such small transparent or translucent crystals or crystal fragments were chosen, that in transmitted light, by the aid of a lens were seen to be pure and free from inclusions and from any adherent material. They were treated with weak hydrochloric acid to remove any adhering calcite, washed and dried and their specific gravity carefully taken with a pygnometer at about 65° F. It was 3·674. The material was then dried, powdered, dried at 100° C. and subjected to analysis. A synopsis of the method used is as follows: Silica was separated by the usual sodium carbonate fusion. Iron separated as a basic acetate and tested for silica. Zinc precipitated in the filtrate as a sulphide and determined by changing to a carbonate. The manganese was then separated from the lime and magnesia by bromine and converted into phosphate. In the filtrate the lime was separated from magnesia as an oxalate and the magnesia determined as a phosphate.

The analysis gave the following results:

	1.	2.	Mean.	Ratio.		
SiO_2	45·96	46·15	46·06	·7676	·7676	1·00
FeO	3·56	3·70	3·63	·0504	·7819	1·02
ZnO	7·39	7·28	7·33	·0905		
MnO ...	34·45	34·11	34·28	·4828		
CaO	7 05	7·03	7·04	·1257		
MgO	1·22	1·38	1·30	·0325		
Total ...	99·63	99·65	99·64			

This gives the correct formula for a meta-silicate R SiO_3. It does not show however that there is any definite ratio in the isomorphous mixture of the molecules of the different silicates present.

In closing, the author desires to express his thanks to Prof. G. J. Brush for his kindness in affording the material upon which this investigation was made and to Prof. S. L. Penfield for valuable assistance and advice.

Mineralogical Laboratory of the Sheffield Scientific School,
New Haven, Conn., May, 1890.

ART. LXIV.—*Some Observations on the Beryllium Minerals from Mt. Antero, Colorado;* by S. L. PENFIELD.

DURING the past few years crystals of beryl, bertrandite and phenacite have been abundantly found associated with one another at Mt. Antero and Mt. White, one of its spurs. They are either implanted on granite or on crystals of the granitic minerals quartz and feldspar, but to my knowledge no very exact data regarding the occurrence of the minerals has been obtained. Owing to the great number of specimens which have been collected, the beauty of the crystals as well as the interesting crystallization of the rare bertrandite and phenacite these minerals have been of unusual interest to mineralogists.

1. *Beryl.*

It is almost certain that beryl is the parent mineral which has furnished the beryllium for the bertrandite and phenacite as both of these occur associated with and frequently implanted on beryl crystals. The beryl occurs in transparent light green and blue prismatic crystals of the aqua-marine variety. They are usually very simple, combinations of the hexagonal prism $10\bar{1}0$ and base 0001 being most common, while occasionally a pyramid of the second order 2-2, $11\bar{2}1$ and the dihexagonal prism $i\text{-}\frac{3}{2}$, $21\bar{3}0$ may be observed. The most interesting feature of the crystals is that, while the material of the beryl is perfectly fresh and transparent, the crystals have been attacked by some solvent and partially dissolved away with the formation of very prominent etchings. The extent to which the crystals have been etched, varies much in the different specimens, while the character of the etching, common to all the crystals, is that the beryl substance is eaten away so as to leave steep pyramidal forms. In all cases there is left, not one single steep pyramid, but a number of them grouped together in parallel position. The action of the solvent has been most energetic at the ends of the crystals. Frequently the whole top of a crystal will be eaten away leaving a very irregular termination composed of groups of fine needles sometimes massed together in a deep depression at the end of a crystal; or some of the basal plane will still be intact, reflecting the light perfectly, while deep pits will be eaten into it, the walls of which represent the sides of the steep pyramids. Again the solvent action seems to have started somewhere along the sides of the prism when a cavity will be eaten into the crystal, sometimes nearly or quite through it, into which the little pyramidal points project. Again the crystals have been almost completely removed from the matrix leaving a hexagonal cavity containing a little cluster of fine beryl needles. If the action has been less prolonged or energetic the etching appears as simple elongated depressions eaten into the prismatic faces.

The steep beryl pyramids, which are seldom 4^{mm} in length, usually have faces and edges which are somewhat rounded so that they appear like needle points, and it was some time before one was obtained which would give in any way satisfactory reflections on the goniometer. At last one was obtained where the needles were unusually large and distinct, and yielded faint reflections which were measured on a horizontal Fuess goniometer, with the lowest ocular, combination δ of Websky.* The most prominent reflections, which occurred twelve times in a complete revolution of the crystal, were from the faces of a dihexagonal pyramid and yielded the following supplement angles, the smaller alternating with the larger: 12°, 47½°, 12½°, 47°, 12½°, 46°, 13°, 46½°, 13°, 46½°, 12½°, 46½°. On close examination it was found that the obtuse angle was above the edge of the unit prism, the two faces making this angle appearing like one face of a pyramid of the second order, for which the steep pyramids were at first taken. Calculating from the average of the angles given above 12° 30′ and 46° 40′ we find that this pyramid has the symbol $12\text{-}\frac{5}{3}$, $36{\cdot}24{\cdot}\bar{6}0{\cdot}5$. The obtuse and acute angles obtained by calculation from the above symbol are 12° 52′ and 46° 15′ using Kokscharow's length of the vertical axis $c=0{\cdot}49886$. A single one of these pyramids, lettered X, in combination with the hexagonal prism *m*, I, $10\bar{1}0$, is shown in fig. 1. The obtuse angle of this pyramid is usually truncated by a pyramid of the second order 12-2, $6{\cdot}6{\cdot}\overline{12}{\cdot}1$, the crystal which was measured giving five faint reflections instead of the possible six, but the faces which are very small are not represented in the figure. Reflections were also obtained from other steep pyramidal forms but they were always faint and could not be referred to definite forms. In addition to the above steep pyramidal forms some of the etched crystals show very distinct facets of a pyramid of the first order making, in two cases which were measured, angles of 40° 31′ and 40° 58′ with the prism and corresponding to the pyramid 2, $20\bar{2}1$ the calculated angle being 40° 57½′. These do not appear as a single pyramid but as a group of pyramids and they occur along with the steep dihexagonal forms on the same crystal. After seeing these beautiful and undoubtedly etched crystals from Mt. Antero there is little doubt that the curiously developed beryl from Willimantic, Ct., previously described in this Journal,* has resulted, as was suggested, by the action of some solvent on a large beryl crystal. If so, the forms thus far observed which have been produced by etching in nature are as follows:

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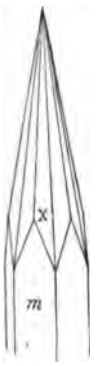
* Zeitsch. Kryst., iv, p. 550.

1.



Mt. Antero.		Willimantic, Ct.	
12-$\frac{5}{3}$	$36\ 24\ \bar{6}0\ 5$	6-$\frac{3}{2}$	$42\bar{6}1$
12-2	$6\ 6\ \bar{1}2\ 1$	3-$\frac{3}{2}$	$21\bar{3}1$
2	$2\ 0\ \bar{2}\ 1$	4-$\frac{4}{3}$	$31\bar{4}1$
		1	$10\bar{1}1$

It is not possible at present to state what solvent has attacked and etched the beryl crystals. The occurrence of octahedral fluorspar with the beryl has suggested that perhaps some fluorine compound has served as a solvent, but as beryl is attacked with great difficulty by hydrofluoric acid this would probably have expended itself on some more readily soluble silicate.

2. *Bertrandite.*

A description of the occurrence and hemimorphic crystallization of this rare silicate, $2Be_2SiO_4, H_2O$, has already been given.† From the examination of a large number of specimens it seems very probable that the beryllium of the bertrandite was obtained from the decomposition and partial solution of the beryl crystals. The growth of the bertrandite before or along with that of the phenacite crystals is also a matter of interest. Mr. Geo. L. English of Philadelphia loaned me from his private collection a beautiful phenacite crystal, fig. 2, which had partially grown over and inclosed a bertrandite and beryl crystal, showing that in this case at least phenacite is a younger mineral than bertrandite.

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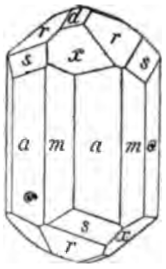
* III, xxxvi, p. 318. † This Journal, xxxvi, 1888, p. 52, and xxxvii, 1889, p. 215.

The author would also acknowledge two corrections which should be made in the first of the above mentioned bertrandite papers. One, pointed out correctly by Carl Vrba,* is that the observed twinning plane is the unit brachydome 1-ĭ, 011 instead of the steeper 3-ĭ, 031. This mistake must be attributed to carelessness on the author's part as seen by reference to his note book. The other is a mistake in the calculation of the vertical axis caused by an error in copying one of the measured angles. The length of the vertical axis should be 0·5993 instead of 0·5953 as pointed out by C. Hintze.†

3. *Phenacite.*

In the present article the author desires to call attention to the very beautiful crystal belonging to Mr. English, which was just mentioned, in which a rather unusual habit is derived, fig. 2, from the almost equal development of the faces at the ends of the crystal, the forms being the same as those already identified and figured,‡ *m*, $10\bar{1}0$, I; *a*, $11\bar{2}0$, *i*-2; *r*, $10\bar{1}1$,+1; *x*, $\bar{1}3\bar{2}2$, $-r\tfrac{3}{2}$-$\tfrac{3}{2}$; *s*, $21\bar{3}1$, $+r$ 3-$\tfrac{3}{2}$ and *d*, $01\bar{1}2$, $-\tfrac{1}{2}$. A number of twin crystals have also been observed in which the base can be taken as the twinning plane and the two crystals, with parallel axes, show reëntrant angles only between the rhombohedrons at the ends, fig. 3. Some of these are of almost ideal symmetry.

2.



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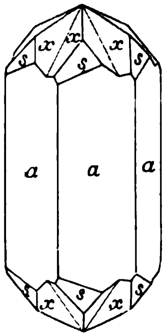

Mineralogical Laboratory of the Sheffield Scientific
School, New Haven, March, 1890.

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[*] Zeitschr. Kryst., xv, p. 470.

[†] Handb. der Mineralogie, p. 413, 1890.

[‡] This Journal, xxxiii, 1887, p. 133, and xxxvi, 1888, p. 321.

SCIENTIFIC INTELLIGENCE.

I. CHEMISTRY AND PHYSICS.

1. *On the Action of Light on Chlorine water.*—It is frequently assumed that when an aqueous solution of chlorine is exposed to light, the whole of the chlorine unites with the hydrogen of the water setting free an equivalent quantity of oxygen. PEDLER has investigated this reaction, using the sunlight of Calcutta to effect it. He finds that chlorine and water have comparatively little action on each other, even in tropical sunlight, when the number of water molecules is not more than one hundred times the number of chlorine molecules. When the number of water molecules is 150 times that of the chlorine molecules, the action may reach 50 per cent of that actually possible. And even when it reaches 400 times, the reaction, while more rapid, reaches only four-fifths of the possible amount. In ordinary chlorine water, saturated at 30°, there is about 0·5566 grams of chlorine in 100 c. c. of water; or about 708 molecules of water to each molecule of chlorine. So that with such a solution, the decomposition may be expected to be both more rapid and more complete. Experiments with this solution show that in full sunlight the main reaction which takes place is that represented by the equation $(H_2O)_2+(Cl_2)_2=(HCl)_4+O_2$; while in feeble diffused light, the reaction at first is probably $H_2O+Cl_2=HCl+HClO$; this hypochlorous acid being in its turn decomposed by light and yielding chloric acid. So that the final reaction is $(Cl_2)_4+(H_2O)_4=(HCl)_7+HClO_3+O$. Hence the action of chlorine on water is, in its first stages at least, quite similar to that of chlorine on cold dilute solutions of potassium or sodium hydrate. In its second stage, the action of chlorine on water is similar to its action on hot concentrated solutions of these hydrates.—*J. Chem. Soc.*, lvii, 613, July, 1890. G. F. G.

2. *On the Action of Light on Phosphorus.*—PEDLER has extended to phosphorus his investigations upon the action of light upon chemical substances. A glass tube was filled with a nearly saturated solution of phosphorus in carbon disulphide, sealed and exposed to full sunlight. In a few minutes a yellowish red coating began to form on the sides of the tube, and continued until the interior was covered. After about three weeks' daily exposure to sunlight, the tube was opened and the precipitate examined. After washing with carbon disulphide, a bright red powder was obtained, which under the microscope appeared to be a mixture in about equal parts, of bright sulphur-yellow particles and bright red particles. The powder remained unchanged in the air, and was unacted on by water, alcohol, ether, benzene and carbon tetrachloride. A warm dilute solution of sodium hydrate, however, dissolved it readily with evolution of gaseous hydrogen phosphide. On cautious heating, the yellow portion sublimed, leaving the red portion. The sublimate was partially soluble in

carbon disulphide, and the solution contained ordinary phosphorus. Moreover, the yellow undissolved portion burned in the air like ordinary phosphorus. Similar experiments were made with other solvents or in vacuo, with similar results. When diffused daylight only was employed, the first precipitate was sulphur-yellow, passing to orange and after some months to a bright red. It was readily dissolved by dilute sodium hydrate solution, on boiling. As the particles of allotropic phosphorus grow larger, they appear to deepen in color. Formed at high temperatures, the precipitate is darker in color. Comparing this product with commercial red phosphorus, and with the so-called metallic or rhombohedral phosphorus, the author concludes that the term "amorphous" is misleading since the great bulk of the powder thus designated consists of transparent ruby-red, more or less crystalline particles which polarize light. By elutriation, it can be separated into a very fine red powder, and into almost black shining particles which under the microscope are crystalline and transparent, transmitting a ruby-red light. Both are acted on by sodium hydrate solution, the action being greater as the particles are finer. Moreover, on heating the red phosphorus to 305°–310° for two hours or even to 326° or 357° no sign of any change could be detected in it. But at 445°, the temperature of boiling sulphur, a certain amount of vapor was produced which was oxidized on contact with the air. In vacuo, about one-fifth of the red phosphorus sublimed as ordinary phosphorus into the upper and cooler portions of the tube, when heated at 445°. The author believes therefore that no change takes place in red phosphorus below 358°, and that even up to 445° it is exceedingly slow. Experiments upon the permanency of this variety of phosphorus in the open air showed that so far from being the inert and stable substance it is usually supposed to be, it is prone to change, being easily oxidized even in the air, and readily deoxidizing phosphoric acid. The so-called metallic phosphorus, prepared either by dissolving ordinary phosphorus in lead at high temperatures, or better by projecting red phosphorus on the surface of melted lead, and then removing the lead with nitric acid, was obtained as a crystalline powder consisting of rhombohedrons, some darker and some lighter in color than the ordinary red phosphorus. This variety of phosphorus polarizes light in the same manner, is acted upon similarly with sodium hydrate and behaves in a similar manner when heated. Hence the author concludes that the metallic and the red are the same allotropic form of phosphorus, and recommends that the term "amorphous" be discarded.—*J. Chem. Soc.*, lvii, 599, July, 1890. G. F. B.

3. *On the Action of Fluorine on Carbon.*—MOISSAN has observed that fluorine and carbon combine with great energy even at ordinary temperatures. Lampblack, purified and dry, becomes incandescent at once in fluorine and wood-charcoal takes fire in it spontaneously. Denser forms become incandescent in fluorine only on heating to 50° or 100°. Graphite from cast iron unites with fluorine below redness and Ceylon graphite and gas carbon

at a red heat. If the carbon be in excess, and the temperature be not allowed to rise too high, the product is carbon tetrafluoride CF_4, a colorless gas liquefying at 10° under a pressure of five atmospheres. In contact with an alcoholic solution of potassium hydrate, it yields potassium fluoride and carbonate. It is not decomposed by the electric spark and is soluble in carbon tetrachloride, alcohol and benzene. At a red heat, the action of fluorine on carbon yields a gaseous carbon fluoride which is not absorbed by alcoholic potash and is almost insoluble in water although it is dissolved by alcohol.—*C. R.*, cx, 276; *J. Chem. Soc.*, lviii, 557, June, 1890. G. F. B.

4. *On Selenic acid.*—CAMERON and MACALLAN have prepared pure selenic acid H_2SeO_4 and have compared its properties with those of sulphuric acid. The anhydrous acid was obtained by evaporating the dilute acid on the water bath and then agitating it in a vacuum at 180° as long as acid distilled over. On cooling the residual acid, it crystallized in hexagonal prisms; and on analysis it was found to contain 99·71 per cent of H_2SeO_4. In the solid form selenic acid has a density of 2·9508. It fuses at 58°, giving a colorless oily liquid of density 2·6083. The presence of a small quantity of water greatly lowers its freezing point, so that it does not solidify until cooled to —51·5°. It attracts moisture strongly, blackens organic matter and evolves acraldehyde by its action on glycerin. A solid hydrate H_4SeO_5, fusing at 25°, is obtained by boiling the dilute acid until the temperature rises to 205° and then dropping a crystal of the acid into the cooled liquid. When heated in a vacuum to 200°, selenic acid decomposes into selenous oxide, oxygen and water. The acid dissolves sulphur at 63° with a deep indigo-blue color. Selenium when thus dissolved gives a green solution and tellurium a purple-red one, both solutions evolving selenous oxide after a time and becoming colorless. Selenic oxide could not be prepared by passing selenous oxide and oxygen over heated platinum sponge, nor by the action of ozone on selenous oxide. But when pure selenic acid was mixed with phosphoric oxide and heated to 100°, crystals were obtained on cooling which on analysis gave results agreeing with the formula SeO_3.—*Proc. Roy. Soc.*, xlvi, 13; *J. Chem. Soc.*, lviii, 688, July, 1890. G. F. B.

5. *On the use of the Platinum Thermometer.* E. H. GRIFFITHS describes the form of instrument used as follows: A coil of fine platinum wire was wound on a roll of asbestos paper and slipped into a thin hard-glass tube. Thick platinum wires ran from this coil to the top of the instrument, and the unimmersed portion of the stem was surrounded by the outer tube of a condenser, and kept at a constant temperature by a flow of tap-water. The resistance of this stem was so small that the change in resistance caused by the changes in the temperature of the tap-water might be neglected. The diameter of these thermometers was less than $\frac{3}{16}$ of an inch, and their length about eighteen inches. They were extremely sensitive, and could therefore be used to trace the rise in temperature due to suffusion, the freezing points

of the metals experimented upon being determined by the limit of this rise. These thermometers were graduated by the temperature of the boiling points of water, naphthalene, benzophenone, and sulphur, and the freezing point of water. The chief difficulties which presented themselves were: Variations in the resistance of the connections between the thermometer coil and the resistance coils; variations in the temperature of the resistance coils themselves; the rise in temperature of the thermometer coil due to the current used when measuring its resistance; the presence of currents due to thermal effects; superheating during distillation, and radiation from the source of heat to the thermometer; the changes in boiling points due to changes in the barometer; oxidation of the metals when fluid.

The mean values obtained are as follows: boiling point of aniline 184°·27, of methyl salicylate 223°·12, of mercury 357°·60.

The results given bear out the following conclusions: I. That although the curves of platinum temperature obtained from different thermometers vary considerably, intermediate temperatures deduced from these curves are in practical agreement. II. That thermometers made and graduated as described may be used for the accurate determination of temperatures up to about 500° C.—*Proc. Roy. Soc.*, No. 294, p. 220.

6. *True weight of a cubic inch of distilled water.* H. J. Chaney has obtained the following value for the weight of a cubic inch of water, 252·286 ± 0·002 grains, of which grains the imperial pound contains 7000 grains, with $t = 62°$, and the barometer at 30 inches.—*Proc. Roy. Soc.*, No. 294, p. 230.

7. *Heat as a Form of Energy*, by R. H. Thurston. 261 pp. 12mo. Boston and New York, 1890 (Houghton, Mifflin & Co. The Riverside Science Series, vol. iii).—This is a very readable presentation of the subject of Heat, particularly in its application as a motor. It opens by developing the growth of the modern idea of heat as a kind of energy, and goes on to explain the science of thermo-dynamics. After this comes the subject of the transformation of heat into mechanical work with an account of gas and coal engines, their growth and present limitations, and the possible directions of progress in the future.

8. *Sound, Light and Heat.* A class book for the elementary stage of the Science and Art Department, 223 pp.; by J. Spencer. *Magnetism and Electricity.* 163 pp. By J. Spencer. London, 1890. (Percival & Co.)—These little volumes are examples of the many elementary science text-books called out by the English system of examinations, but which are fitted to be useful in a larger field. They include the fundamental principles in the several branches of physics named, with numerous simple diagrams and an abundance of exercises, for calculation and experiment.

II. GEOLOGY AND MINERALOGY.

1. *Geological and Palæontological relations of the Coal and Plant-bearing beds of Palæozoic and Mesozoic age in Eastern Australia and Tasmania; with special reference to the Fossil*

Flora, by OTTOKAR FEISTMANTEL, Mem. Geol. Surv. N. S. W., *Palæontology*, *No.* 3. Sydney, 1890, 183 pp., xxx pl., 4°.—The basis of this valuable memoir, by one to whom we are especially indebted for knowledge of the fossil floras of the Paleozoic and Mesozoic of India and Australia, is a translation of his contributions published in the third Supplement-volume of Palaeontographica, 1878–79. The entire work, including the complete historical and bibliographic data, has undergone thorough revision and considerable enlargement. Numerous annotations are added by Mr. C. S. Wilkinson, Director of the Geological Survey of New South Wales, and Mr. R. Etheridge Jr., the editor of the present memoir. The paleontological part of the work consists chiefly of systematic descriptions of all the fossil fishes, amphibia, and plants that have been described from the above epochs in Australia, with a table of their distribution. Two new species, *Glossopteris gangamopteroides* from the Newcastle beds, and *G. spathulato-cordata* from the same beds and the Mersey coal beds (Permian ?) of Tasmania, are described. Much interest and some controversy between animal and vegetable paleontologists have been aroused in the determination of the age of the Australian deposits, on account of the mingling of a Mesozoic flora with a Paleozoic fauna for a period extending from the Lower Carboniferous probably to the Jurassic. Dr. Feistmantel, agreeing substantially with the resident geologists, assigns the Goono Goono and lower *Lepidodendron* beds of Queensland and Victoria to the Devonian; the Smith's Creek, Port Stephens and Bobuntungen beds with *Calamites radiatus*, *Rhacopteris inæquilatera*, *Archæopteris*, and *Lepidodendron Veltheimianum*, to the Lower [Sub-?] Carboniferous; the "lower coal measures" with *Phyllotheca*, *Glossopteris*, *Nœggerathiopsis*, etc., the forerunners of the Mesozoic flora, occurring between marine beds with a middle and upper Carboniferous fauna, to the Upper part of the Carboniferous; the "upper coal measures," an overlying series of coal beds and other fresh-water deposits, with *Phyllotheca*, *Vertebraria*, *Glossopteris*, *Gangamopteris* and *Urosthenes*, a heterocercal fish, at Newcastle, are relegated to the Permian; while the Hawkesbury-Wianamatta Series, with heterocercal fish, which if alone would be considered Permian, is placed in the Trias, the Clarence River series being called Jurassic. Exception is taken by Mr. Wilkinson to the definite correlation of the Baccus Marsh "Bowlder-bed" of Victoria with those in the marine series of New South Wales almost entirely on account of the supposed glacial origin of the bowlder-beds. The correlation of the Australian with the Chinese, Indian, Afghan, and South African plant bearing terranes corresponds for the most part with that published in the Prag Sitzungsberichte since this memoir was prepared, (1888). The descriptive text is illustrated by thirty plates of plants and fishes. The former are carefully re-drawn and rearranged from the German work with the addition of new material. The latter include drawings of the three species of *Palæoniscus*, *Cleithrolepis*, and *Myriolepis* from the Hawkesbury-Wiantta and a reproduction of Dana's *Urosthenes* from the wcastle beds. D. W.

. *Jurassic Fish-Fauna in the Hawkesbury beds of New South les.* An abstract of a memoir by A. SMITH WOODWARD nals and Magazine of Natural History, Nov. 1890), mentions discovery of a large collection of fossil fishes in the Hawkes-y series of Talbralgar, New South Wales, which prove to resent a typical Jurassic fish-fauna. The genera identified lude *Coccolepis* and *Leptolepis,* also new forms allied to *Semio-us,* to the *Dapedioids* and to *Leptolepis,* respectively. Another er describes an early Mesozoic fish-fauna discovered some rs ago in the Hawkesbury beds at Gosford, N. S. W.

. *On the state of Alpine glaciers in* 1889, by F. A. FOREL. n 1889 the commencement of a forward movement was ved in the case of two glaciers of the first rank, the Rhone cier and the Glacier des Bois at Chamounix, as well as of two three small glaciers of the Ortler group. The number of ciers, now on the increase, has become 55 for the whole Alps, tributed as follows: all the glaciers of Mont Blanc; a large portion of glaciers in the Bernese and Valais Alps; some ated glaciers in the Pelvoux region (Dauphiné) and in the ler (Tyrol). With the exception of the Ortler group, all the ciers of the Austrian and Grison Alps are still receding or are tionary.—*Bibl. Univ.*, III, xxiv, 87, 1890.

. *Cordierite as a contact mineral.*—Y. KIKUCHI has studied tain cordierite rocks of Japan, from the bordering region of provinces Kōdsuke and Shimotsuke, along the Watarase-va. The cordierite occurs here in slate as a product of con-t-metamorphism with granite. It shows various peculiarities form and structure, and is especially characterized by the sence of symmetrically arranged inclusions of black carbona-us matter. It is thus strikingly like the variety of andalusite ed chiastolite, and the author proposes to call it *cerasite,* from *ασος cherry.* This word alludes to the Japanese name ura-ishi, or cherry-stone, locally given to the cordierite slate, ause the structure of the stellar aggregates of the cordierite mbles a cherry-blossom, and also from the same resemblance a similar rock where the forms are now only pseudomorphs. *ourn. Coll. Soc. Tokyo,* iii, 313, 1890.

. *Sanguinite, a new mineral.*—Dr. Miers has given the name guinite to a mineral found upon specimens of argentite from ñarcillo, Chili. It occurs in minute hexagonal scales, optically axial. The color is dark red and the streak dark purplish wn. Qualitative trials make it probable that the mineral is a harsenite of silver, allied to proustite, with which it is asso-ed, but with which it cannot be united.—*Min. Mag.*, ix, 182.

III. MISCELLANEOUS SCIENTIFIC INTELLIGENCE.

. *Deep-sea Dredging in the Pacific.*—Professor ALEXANDER ASSIZ informs the editors that he is to join the "Albatross" and superintend the dredging of the lines which had been laid out for the Albatross at the time she was on her way from New York to San Francisco. The work will begin at Acapulco about the first of February, a line of soundings, temperatures and dredgings being run to the Galapagos and one from the islands to Panama. At Acapulco, the Galapagos and Panama a number of short lines will be run from the 100-fathom line into deep water. It is hoped also to devote some time to the unsettled question of the vertical distribution of pelagic life, not only near the anti-neutral slopes but also in the deep water half way between the Galapagos and the continent. Under so favorable conditions, with a vessel so well equipped as the "Albatross" and with the benefit of the experience of earlier deep-sea explorers, important results may be anticipated from this work.

2. *National Academy of Sciences.*—The following is a list of papers accepted for reading at the meeting of the Academy held in Boston, Nov. 11–13:

R. H. Chittenden: Primary cleavage products formed in the digestion of the albuminoid, gelatin.

Edward C. Pickering: Classification and distribution of stellar spectra.

R. Catlin: Relation of atmospheric electricity, magnetic storms and weather elements, to a case of traumatic neuralgia.

Henry P. Bowditch: Growth of children studied by Galton's method of percentile grades.

John Trowbridge: Electrical oscillations in air, together with spectroscopic study of the motions of molecules in electrical discharges.

Charles R. Cross: Some considerations regarding Helmholtz's theory of dissonance.

W. A. Rogers: A critical study of a combined meter and yard upon a surface of gold, the meter having subdivisions to two millimeters, and the yard to tenths of inches; Evaporation as a disturbing element in the determination of temperatures.

J. Walter Fewkes: Use of the phonograph in the study of the languages of the American Indians

Francis A. Walker: Probable loss in the enumeration of the colored people of the United States, at the census of 1870.

H. A. Newton: Capture of periodic comets by Jupiter.

Thomas B. Osborne: Proteids of the oat kernel.

S. C. Chandler: Present aspect of the problems concerning Lexell's comet.

J. S. Newberry: Great Falls coal field, Montana, its geological age and relations.

Wolcott Gibbs: Separation of the oxides in cerite, samarskite and gadolinite.

Theo. Gill: Relationships of the Cyclopteroidea.

Amos E. Dolbear: Origin of electro-magnetic waves.

3. *Results of a Biological Survey of the San Francisco Mountain Region and Desert of the Little Colorado, Arizona*, pp. 136. Washington, 1890. (North American Fauna No. 3).—U. S. Department of Agriculture, Division of Ornithology and Mammalogy.—This volume contains papers by Dr. C. Hart Merriam on the geographical and vertical distribution of species with annotated lists of mammals and also a similar list of birds; further a paper of Dr. Leonhard Stejneger giving an annotated list of reptiles and batrachians. The memoirs are accompanied by a series of plates, and an interesting colored biological map of North America (Jan. 1890) showing the principal life areas.

4. *Bulletin of the Scientific Laboratories of Denison University.* Edited by W. G. TIGHT, M. S. Vol. V. pp. 94. Granville, O., June, 1890.—This volume includes besides a series of Laboratory notes, papers by W. F. Cooper on the Waverly Group, with a tabulated list of fossils known to occur in the Waverly of Ohio, and by C. L. Herrick and W. G. Tight on the central nervous system of rodents; the last paper is illustrated by 19 plates.

5. *Royal Society of Canada.* Memoirs for the year 1889, Tome VII.—Contains in its geological and natural history section, papers by L. W. Bailey, on New Brunswick geology, with his Presidential Address; by Sir J. Wm. Dawson, on the sponges of Little Metis and on some Mackenzie River fossil plants; J. F. Whiteaves, on Lower Silurian fossils of Manitoba; A. H. MacKay, on freshwater sponges of Canada and Newfoundland; A. P. Coleman, geography and geology of the big bend of the Columbia; E. J. Chapman, on a new classification of trilobites, as influenced by stratigraphical relations; G. F. Matthew, Cambrian organisms in Acadia; J. W. Spencer, the Iroquois Beach; G. C. Hoffmann, hygroscopicity of Canadian fossil fuels.

6. *Ostwald's Klassiker der Exakten Wissenschaften*, Leipzig, 1890 (Wm. Engelmann.).—Recent issues of this valuable series include the following:

No. 13. Vier Abhandlungen über die Elektricität und den Magnetismus von Coulomb. (1785–1786).

No. 14. Die vier Gauss'schen Beweise für die Zerlegung ganzer Algebraischer Functionen in reelle Factoren ersten oder zweiten Grades. (1799–1849).

Nos. 15, 16. Chemische Untersuchungen über die Vegetation von Théod. de Saussure (1804).

Dictionary of the Language of the Micmac Indians, pp. 286, by Rev. S. T. Rand, Halifax, N. S. This volume, published by the Canadian government, is an important contribution to philology. It is one of several important works in this field by the late Dr. Rand (1810–1889), who was long a missionary among the Micmac Indians, an aboriginal tribe of the Algonquin family inhabiting the Maritime Provinces of the Dominion of Canada.

Index to the Literature of Thermodynamics, pp. 238, by Alfred Tuckerman, Smithsonian Institution, Washington, 1890. (Smithsonian Miscellaneous Collections, No. 741).

Investigations of the New England Meteorological Society for the year 1889. reprinted from the Annals of the Astronomical Observatory of Harvard College, Edward C. Pickering, director. Vol. xxi, Part II, pp. 107–273. Cambridge, 1890.

Proceedings of the United States National Museum, pp 686. Vol. 12, 1889. Washington, 1890.

A Revision of the South American Nematognathi or Cat fishes, 508 pp., by Carl H Eigenmann and Rosa S. Eigenmann. Also—

Land Birds of the Pacific District, 274 pp., by Lyman Belding, San Francisco, 1890.—These valuable memoirs form Parts I and II of the Occasional Papers of the California Academy of Sciences.

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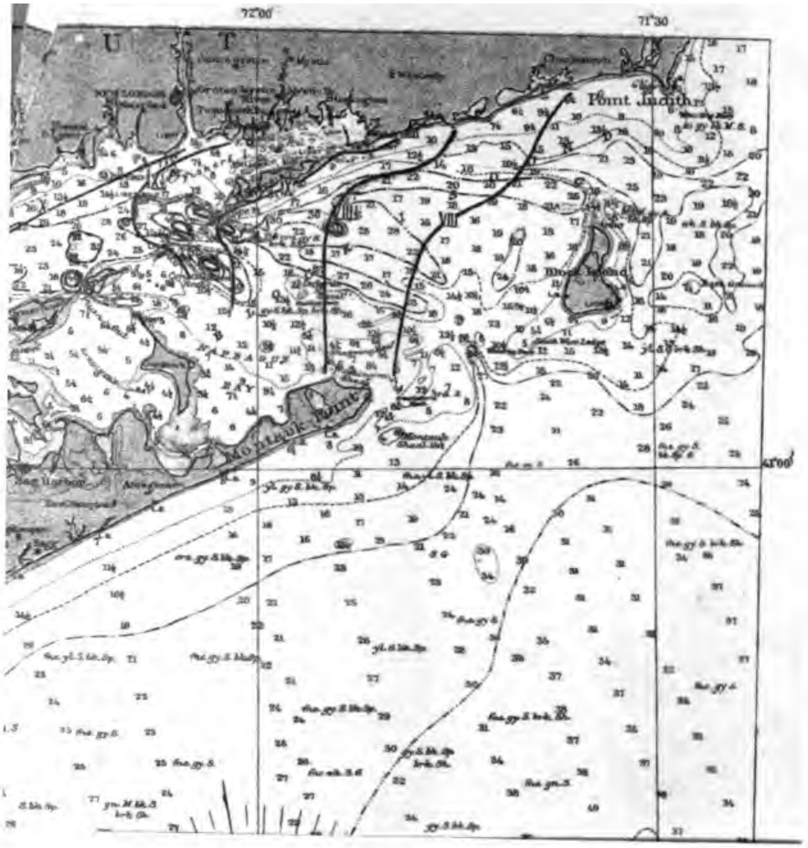
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VIII

GENERAL INDEX

OF

VOLUMES XXXI-XL OF THE THIRD SERIES.

☞ In the references to volumes xxxi to xxxix, only the numerals i to ix are here given.

NOTE.—The names of Minerals are inserted under the head of MINERALS: all Obituary notices are referred to under OBITUARY. Under the heads BOTANY, CHEMISTRY, GEOLOGY, ROCKS, ZOOLOGY the references to the topics in these departments are grouped together; in most cases, however, the same references appear elsewhere, at least under the author's name.

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